Worked Example (Scheme of Separating a Mixture)

I. *Devising a scheme to separate a mixture of several cations*

An aqueous solution is known to contain the following three cations:
Fe^{3+}(aq), Cu^{2+}(aq) and Zn^{2+}(aq)

Devise a scheme to separate the cations.

Solution

1. Add a little and then excess NaOH(aq) to the solution. Fe^{3+}(aq) and Cu^{2+}(aq) form insoluble brown and blue precipitates respectively. Zn^{2+}(aq) forms a white precipitate first and it dissolves in excess NaOH(aq) to give a colourless solution.

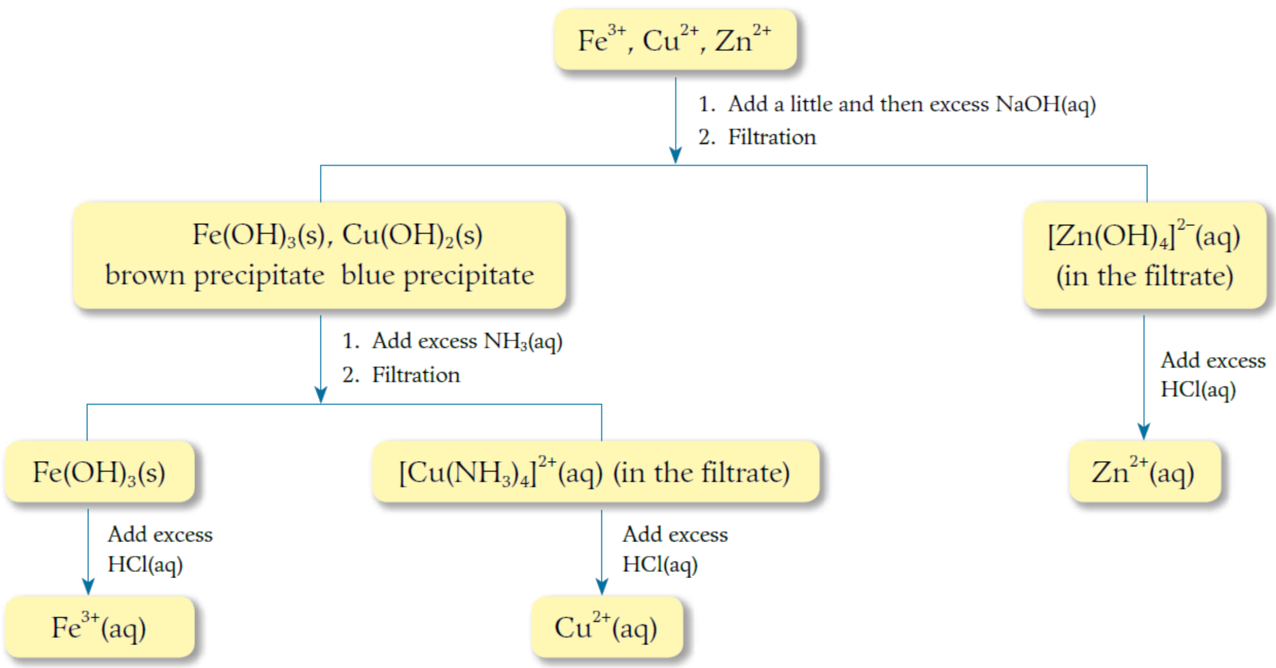
2. Filter the mixture. Add excess HCl(aq) to the filtrate and the resultant solution contains Zn^{2+}(aq).

3. Add excess NH_3(aq) to the residue. Only the blue precipitate dissolves to give a deep blue solution.

4. Filter the mixture. Add excess HCl(aq) to the filtrate and the resultant solution contains Cu^{2+}(aq).

5. Add excess HCl(aq) to dissolve the brown precipitate (residue). This solution contains Fe^{3+}(aq).

The following flow diagram summarizes the above scheme:



II. *Devising a scheme to separate a mixture of several anions*

An aqueous solution is known to contain the following three anions:

CO_3^{2-}(aq), NO_3^-(aq) and Cl^-(aq)

Devise a scheme to separate the anions in the solution.

Solution

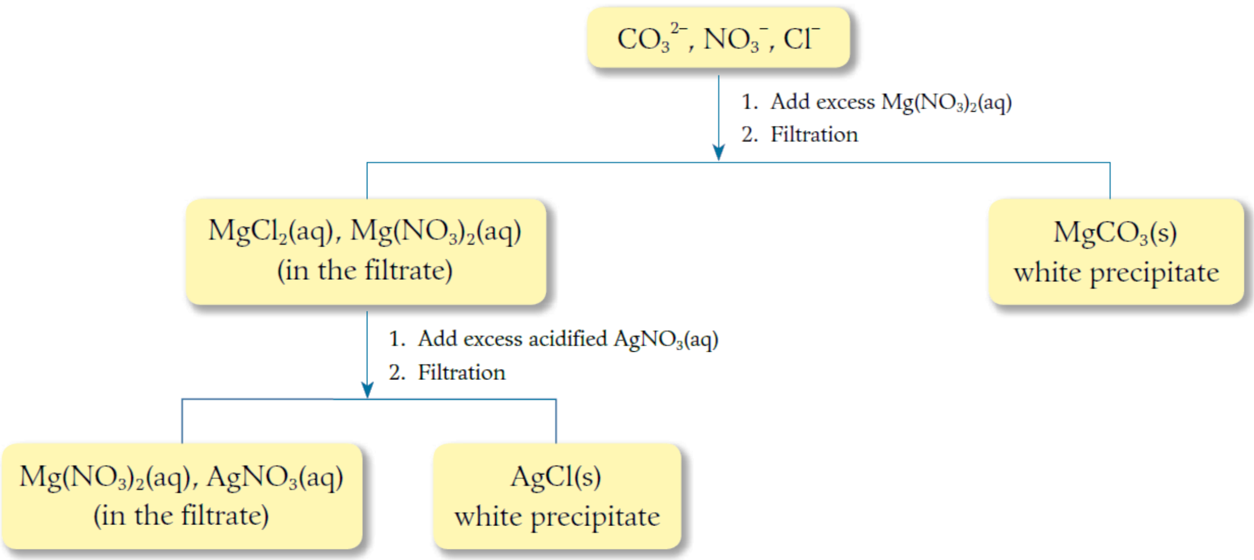
1. Add excess $Mg(NO_3)_2$(aq) to the solution. CO_3^{2-}(aq) forms insoluble white precipitate $MgCO_3$(s) with Mg^{2+}(aq).

2. Filter the mixture. The residue is $MgCO_3$(s). The filtrate contains NO_3^-(aq) and Cl^-(aq).

3. Add excess acidified $AgNO_3$(aq) to the filtrate. Cl^-(aq) forms insoluble white precipitate AgCl(s) with Ag^+(aq).

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

The following flow diagram summarizes the above scheme:



III. Devising a scheme to separate a mixture of organic compounds

Devise a scheme to separate a liquid mixture containing hexane and hexanoic acid. Outline the procedure for the separation.

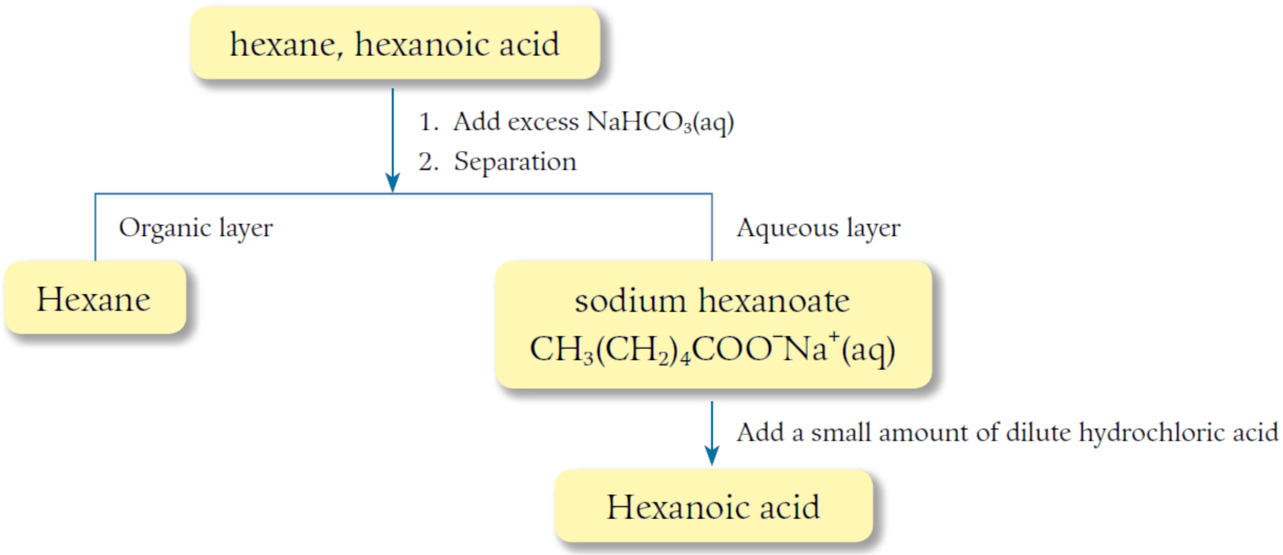
Solution

1. Add excess sodium hydrogencarbonate solution to the mixture in a separating funnel and shake the mixture. Hexanoic acid reacts with sodium hydrogencarbonate solution and dissolves in the solution (aqueous layer). Hexane has no reaction and forms the organic layer.

2. Allow the aqueous layer and organic layer to separate. Run off the aqueous layer.

3. Regenerate hexanoic acid by adding a small amount of dilute hydrochloric acid to the aqueous layer.

The following flow diagram summarizes the above scheme:



IV. *Justifying the choice of an appropriate method for the separation of substances in a mixture*

(a) A student is going to separate a mixture of hexane and water by simple distillation because he thinks that there is a large difference in boiling points between them (b.p. of hexane = 69°C, b.p. of water = 100°C). Do you think it is a proper method? Explain your answer.

(b) Now, he is going to separate another mixture of hexane and hexan-1-ol (b.p. of hexane = 69°C, b.p. of hexan-1-ol = 156.4°C). Do you think it is proper to use simple distillation to separate them? Explain your answer.

Solution

(a) Hexane and water are immiscible. It is not proper to use simple distillation to separate the mixture. The mixture should be separated by using a separating funnel.

(b) Hexane and hexan-1-ol are miscible. The mixture can be separated by simple distillation as there is a large difference in boiling points between hexane and hexan-1-ol.