Chapter 4. Analytical Chemistry

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Solution 1:

1. Cuprous salts = Colourless
2. Cupric salts = Blue
3. Aluminium salts = Colourless
4. Ferrous salts= Light green
5. Ferric salts = Yellow
6. Calcium salts = Colourless

Solution 2:

(a) Ferrous ion and Ferric ion.

(i) $FeSO_4 + 2NH_4OH \rightarrow Fe(OH)_2\downarrow + (NH_4)_2SO_4$

$Fe(OH)_2$ forms dirty green precipitates.

(i) $Fe_2(SO_4)_3 + 6NH_4OH \rightarrow 2Fe(OH)_3\downarrow + 3(NH_4)_2SO_4$

$Fe(OH)_3$ forms reddish brown precipitates.

(b) Zinc ion and Lead ion.

(i) $ZnSO_4 + 2NH_4OH \rightarrow Zn(OH)_2\downarrow + (NH_4)_2SO_4$

$Zn(OH)_2$ forms white gelatinous precipitates. In the presence of excess of ammonium hydroxide these precipitates get dissolved .

(ii) $Pb(NO_3)_2 + 2NH_4OH \rightarrow Pb(OH)_2\downarrow + 2NH_4NO_3$

$Pb(OH)_2$ forms white precipitates. This precipitate is insoluble in the presence of excess of ammonium hydroxide

Concept Insight: Ammonium hydroxide forms insoluble hydroxides when treated with certain metallic salt solutions. The insoluble hydroxides thus formed get precipitated in the form of a precipitate and may be identified by their distinct colours.

Solution 3:

By use of Ammonium hydroxide we can identify the ions $PbCO_3$, $ZnCO_3$ and $CaCO_3$ as:

(i) $PbCO_3 + 2NH_4OH \rightarrow Pb(OH)_2\downarrow + 2NH_4NO_3$

$Pb(OH)_2$ forms white precipitate which are insoluble in excess ammonium hydroxide.

(ii) $ZnCO_3 + NH_4OH \rightarrow Zn(OH)_2\downarrow + 2Na_2CO_3$

$Zn(OH)_2$ forms white gelatinous precipitate which are soluble in excess ammonium hydroxide.

(iii) $CaCO_3 + NH_4OH \rightarrow Ca(OH)_2 + 2Na_2CO_3$

No precipitation of $Ca(OH)_2$ occurs even with addition of excess of NH_4OH. Because the concentration of hydroxide ion from ammonium hydroxide is so low that it cannot precipitate the hydroxide of calcium.

Concept Insight: Some precipitated metallic hydroxides by ammonium hydroxide become soluble hydroxides when treated with excess of ammonium hydroxide due to the formation of a soluble complex salt in the presence of excess of ammonium hydroxide.

Solution 4:
K_2SO_4.

Solution 5:

(a) Addition of caustic soda to $FeCl_3$ solution:

$FeCl_3 + 3NaOH \rightarrow Fe(OH)_3\downarrow + 3NaCl$

Reddish Brown ppt.

(b) Addition of caustic soda to $ZnSO_4$ solution:

$ZnSO_4 + 2NaOH \rightarrow Zn(OH)_2\downarrow + Na_2SO_4$

White gelatinous ppt.

(c) Addition of caustic soda to $Pb(NO)_3$ solution:

$Pb(NO)_3 + 2NaOH \rightarrow Pb(OH)_2\downarrow + 2NaNO_3$

White ppt.

(d) Addition of caustic soda to $CuSO_4$ solution:

$CuSO_4 + 2NaOH \rightarrow Cu(OH)_2\downarrow + Na_2SO_4$

Pale blue ppt.

Solution 6:

The reaction of freshly precipitated aluminium hydroxide with caustic soda solution is as:

$Al(OH)_3 + NaOH \rightarrow NaAlO_2 + 2H_2O$

Sodium aluminate

(White)

Solution 7:

Amphoteric oxides : Amphoteric oxides are those compounds, which react with both acids and alkalis to form salt and water.

For example: Oxides of Aluminium, zinc and lead are amphoteric in nature.

Balanced equations for the reaction of different amphoteric oxides with a caustic alkali:

Amphoteric oxide + Alkali → Salt + Water

(a) $ZnO + 2NaOH \rightarrow Na_2ZnO_2 + H_2O$

White Sodium zincate (Colourless)

(b) $Al_2O_3 + 2NaOH \rightarrow NaAlO_2 + 2H_2O$

White Sodium aluminate

(White)

(c) $PbO + 2NaOH \rightarrow Na_2PbO_2 + H_2O$

Yellow Sodium plumbite (colourless)

Solution 8:

(a) $Zn(OH)_2$ from $Pb(OH)_2$: Ammonium hydroxide (NH_4OH) solution can separate $Zn(OH)_2$ from $Pb(OH)_2$ as $Zn(OH)_2$ precipitates are dissolved in excess of NH_4OH solution while $Pb(OH)_2$ precipitates are insoluble in excess of NH_4OH solution.

(b) CaO from PbO: Sodium hydroxide solution can separate CaO from PbO as CaO precipitates are sparingly soluble in excess of NaOH solution while PbO precipitates are soluble in excess of NaOH solution.

(c) CuO from ZnO: Sodium hydroxide solution can separate CuO from ZnO as CuO precipitates remains insoluble in excess of NaOH solution while ZnO precipitates are soluble in excess of NaOH solution.

Solution 9:
Examples of amphoteric hydroxides are: Zn(OH)2, Al(OH)3.

Solution 10:

(a) The powdered metal added to sodium hydroxide solution is Aluminium.

(b) The gas evolved is hydrogen.

(c) The salt present in the colorless solution is sodium aluminate ($NaAlO_2$).

Concept Insight: The alloy of aluminium metal i.e. duraluminium finds use in the construction of aircrafts. Reaction of aluminium metal with sodium hydroxide is as:

$2Al + 2NaOH + 2H_2O \rightarrow 2NaAlO_2 + 3H_2$

Solution 11:

(a) $Zn(OH)_2$

(b) Na_2O.

(c) NaOH

(d) NH_4OH

(e) Cu^{2+}, Mn^{2+}

(f) $Zn(OH)_2$ and $Pb(OH)_2$

(g) PbO

Solution 12:

Ammonia solution is $NH_3 + H_2O \rightarrow NH_4OH$

The general reaction of NH_4OH with metal salt solutions is:

Salt solution +Ammonium hydroxide → Metal hydroxide + salt formed in solution

(a) Dropwise addition of NH_4OH:

$$CuSO_4 + 2NH_4OH \rightarrow Cu(OH)_2 + (NH_4)_2SO_4$$

Blue   Pale blue ppt.

With excess of NH_4OH the precipitate of copper(II) hydroxide dissolves as:

$$Cu(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH \rightarrow [Cu(NH_3)_4]SO_4 + 4H_2O$$

In excess   Tetrammine copper(II)
Sulphate
(Deep blue solution)

(b) Dropwise addition of NH_4OH:

$$ZnSO_4 + 2NH_4OH \rightarrow Zn(OH)_2 + (NH_4)_2SO_4$$

Colourless   White ppt.

With excess of NH_4OH the precipitate of zinc(II) hydroxide dissolves as:

$$Zn(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH \rightarrow [Zn(NH_3)_4]SO_4 + 4H_2O$$

In excess   Tetrammine zinc(II)
Sulphate
(colourless solution)

(C) Dropwise addition of NH_4OH:

$$FeCl_3 + 3NH_4OH \rightarrow Fe(OH)_3 + 3NH_4Cl$$

Yellow   (Dirty green ppt.)

With excess of NH_4OH, the precipitate does not dissolve.

Solution 13:

The chloride of a metal which is soluble in excess of ammonium hydroxide is zinc chloride i.e. ZnCl2.

Solution 14:

(a) Zinc (Zn) metal salt solution was used.

(b) The formula of white gelatinous precipitate is $Zn(OH)_2$.

Concept Insight: $ZnSO_4 + 2NH_4OH \rightarrow Zn(OH)_2 + (NH_4)_2SO_4$

Colourless White ppt

With excess of NH_4OH the precipitate of zinc(II) hydroxide dissolves as:

$Zn(OH)_2 + (NH_4)_2SO_4 + 2NH_4OH \rightarrow [Zn(NH_3)_4]SO_4 + 4H_2O$

In excess Tetrammine zinc(II) Sulphate (colourless solution)

Solution 15:

1. PbO
2. Al2O3
3. Na2ZnO2

Solution 16:

1. transition, Cr^{3+}, Fe^{2+}, MnO_4^{4-}.
2. $Zn(OH)_2$
3. NH_4Cl
4. Al_2O_3, Al
5. NH_4OH

Solution 1992-1:

1. Addition of KCN
2. Addition of excess of NaOH.
3. Addition of excess ofNH_4OH

Solution 1993-1:

(a) Zinc nitrate solution from calcium nitrate solution:

(i) $Zn(NO_3) + 2NaOH \rightarrow Zn(OH)_2 + 2NaNO_3$

On further addition of NaOH, $Zn(OH)_2$ dissolves.

(ii) $Ca(NO_3)_2 + 2NaOH \rightarrow Ca(OH)_2 + 2NaNO_3$

$Ca(OH)_2$ precipitates are sparingly soluble in excess of sodium hydroxide.

(b) Iron (II) chloride from iron (III) chloride

(i) $FeCl_2 + 2NaOH \rightarrow Fe(OH)_2 + 2NaCl$

$Fe(OH)_2$ precipitates are dirty green gelatinous in nature.

(i) $FeCl_3 + 3NaOH \rightarrow Fe(OH)_3 + 3NaCl$

$Fe(OH)_3$ precipitates are reddish brown in colour.

(c) Lead hydroxide from magnesium hydroxide.

When sodium hydroxide is added, lead hydroxide is dissolved in it but when sodium hydroxide is added to magnesium hydroxide, there is no visible reaction i.e. it remains insoluble.

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Solution 1995-1:

1. The metal ion present in solution A is Pb^{2+}
.
2. The cation present in solution B is Cu^{2+}. The probable colour of solution B is blue.

Solution 1996-1:

When sodium hydroxide solution is added to zinc sulphate solution, till it is in excess white gelatinous precipitates of $Zn(OH)_2$ are formed and due to the excess of sodium hydroxide these ppt. get dissolved immidiately:

$$ZnSO_4 + 2NaOH \rightarrow \underset{\text{white gelatinous ppt.}}{Zn(OH)_2} + Na_2SO_4$$

$$Zn(OH)_2 + 2\,NaOH \longrightarrow \underset{\text{colourless}}{Na_2ZnO_2} + 2H_2O$$

Solution 1996-2:

The solutions for the tests will be prepared by dissolving the given powders separately in water.

1. **Solution of Calcium carbonate:**
   Calcium carbonate is $CaCO_3$ and contains Ca^{2+} ions. Sodium hydroxide solution NaOH can be used to identify Ca^{2+} since its addition to calcium carbonate solution will give white precipitates of Ca(OH)2 which are sparingly soluble in excess of NaOH.

1. **Solution of Lead carbonate:**
   Lead carbonate is $PbCO_3$and contains Pb2+ ions. Ammonium hydroxide solution NH4OH

   can be used to identify Pb^{2+} since its addition to lead carbonate solution will give white precipitates of Pb(OH)2 which are insoluble in excess of NH4OH.

2. **Solution of Zinc carbonate:**
   Zinc carbonate is ZnCO3 and contains Zn^{2+} ions. Sodium hydroxide solution NaOH can be used to identify Zn^{2+} since its addition to zinc carbonate solution will give white gelatinous precipitates of $Zn(OH)_3$ which are soluble in excess of NaOH.

Solution 1996-3:

For the reaction that will take place when copper sulphate solution is added to sodium hydroxide solution the equation is as:

$CuSO_4 + 2NaOH \rightarrow Cu(OH)_2 + Na_2SO_4$

Solution 1997-1:

a. (i) **Sodium Hydroxide**

	Small amount	In excess
Calcium nitrate	White precipitate	sparingly soluble
Zinc nitrate	White precipitate	Soluble
Lead nitrate	White precipitate	Soluble

(ii) **Ammonium Hydroxide**

	Small amount	In excess
Calcium nitrate	No visible reaction	No change
Zinc nitrate	White precipitate	Soluble
Lead nitrate	White precipitate	Insoluble

Solution 1998-1:

(a) Sodium hydroxide solution gives dirty green coloured precipitates with iron(II) sulphate solution.

With iron(III) sulphate solution sodium hydroxide solution gives reddish brown precipitates.

(b) When barium chloride solution is added to iron(II) sulphate solution it gives white precipitate of $BaSO_4$.

(c) Sodium carbonate + hydrochloric acid = sodium chloride + water + carbon dioxide

$NaCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$

Sodium sulphite + hydrochloric acid → sodium chloride + water + hydrogen sulphide
$2Na_2SO_3 + 4HCl \rightarrow 4NaCl + 6H_2O + 2H_2S$
Production of Foul smelling hydrogen sulphide gas will easily help to distinguish between sodium carbonate and sodium sulphite.

Solution 1999-1:

(i) Sodium chloride solution and sodium nitrate solution.
Add freshly prepared ferrous sulphate solution to the two solutions. Then by the side of the test tube, pour concentrated sulphuric acid to each slowly. The one in which brown ring appears is sodium nitrate solution while the other is sodium chloride solution.
(ii) Sodium sulphate solution and sodium chloride solution.

Sodium sulphate solution	Sodium chloride solution
When Sodium sulphate solution is treated with Barium chloride solution, a white precipitate is formed which is insoluble in all the mineral acids.	When Sodium chloride solution is treated with Barium chloride solution, no visible reaction is observed.

(iii) Zinc nitrate solution from calcium nitrate solution:

a. $ZnNO_3 + 2NaOH \rightarrow Zn(OH)_2 + NaNO_3$
White gelatinous ppt.

On further addition of NaOH, $Zn(OH)_2$ dissolves.

b. $Ca(NO_3)_2 + 2NaOH \rightarrow Ca(OH)_2 + 2NaNO_3$
White ppt.

$Ca(OH)_2$ precipitates are sparingly soluble in excess of sodium hydroxide.

Solution 2000-1:

(i) $FeCl_2 + 2NaOH \rightarrow Fe(OH)_2 + 2NaCl$
(ii) $2NaOH + Cl_2 \rightarrow NaCl + NaOCl + H_2O$
(iii) $Zn + 2NaOH \rightarrow Na_2ZnO_2 + H_2$
(iv) $SO_2 + 2NaOH \rightarrow Na_2SO_3 + H_2O$

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Solution 2001-1:

(i) Neutral litmus solution turns blue in colour when added to alkaline solution.

(ii) $Fe_2(SO_4)_3 + 6NH_4OH \rightarrow 2Fe(OH)_3 + 3(NH_4)_2SO_4$

Yellow Reddish brown

(iii) $Pb(NO_3)_2 + 2NaCl \rightarrow PbCl_2 + 2NaNO_3$

(iv) Nothing is observed since ethane is a saturated hydrocarbon.
(v) Sulfur burns with a blue flame concomitant with formation of sulfur dioxide, notable for its peculiar suffocating odor.

Solution 2003-1:

(i) Zn^{2+} ions on addition of NH_4OH forms white precipitates of $Zn(OH)_2$ which further dissolves in excess of NH_4OH.
On the other hand, Pb^{2+} ions do form $Pb(OH)_2$ with ammonium hydroxides but these precipitates do not dissolve in excess of NH_4OH.

(ii)

Carbonate	Colour of residue on cooling
Zinc carbonate	White amorphous powder
Lead carbonate	Yellow
Copper carbonate	Bluish green crystalline solid

Solution 2003-2:

(i) Sodium hydroxide when added to zinc sulphate gives gelatinous white precipitate which dissolves in excess of sodium hydroxide.

$$ZnSO_4 + 2NaOH \rightarrow Zn(OH)_2 + Na_2SO_4$$

$$Zn(OH)_2 + 2NaOH \rightarrow Na_2ZnO_2$$

(ii) When ammonium hydroxide is added in small quantity to copper sulphate solution; it gives blue precipitate of $Cu(OH)_2$

$$\underset{\text{Blue}}{CuSO_4} + 2NH_4OH \rightarrow \underset{\text{Pale blue ppt.}}{Cu(OH)_2} + (NH_4)_2SO_4$$

When ammonium hydroxide is added in excess, the blue precipitate dissolves giving deep blue solution of tetra amine copper sulphate.

$$Cu(OH)_2 + (NH_4)_2SO_4 + \underset{\text{In excess}}{2NH_4OH} \rightarrow \underset{\text{Tetrammine copper(II) Sulphate (Deep blue solution)}}{[Cu(NH_3)_4]SO_4} + 4H_2O$$

(iii) Curdy white precipitate of AgCl formed by reaction between hydrochloric acid and silver nitrate solution, dissolves in excess of NH_4OH.

$$AgNO_3 + HCl \rightarrow AgCl + HNO_3$$

$$AgCl + 2NH_4OH \rightarrow Ag(NH_3)_2Cl + 2H_2O$$

(iv) Starch paper turns blue black:

$$2KI + Cl_2 \rightarrow 2KCl + I_2$$

I_2 reacts with starch to give blue black colour.

The chlorine liberates iodine from KI and then it is decolourised.

(v) Pink colour of $KMnO_4$ is discharged.

$$2KMnO_4 + 3H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 5O + 3H_2O \quad -(1)$$

$$\underline{SO_2 + H_2O + O \rightarrow H_2SO_4 \times 5 \quad -(2)}$$

$$2KMnO_4 + 5SO_2 + 2H_2O \rightarrow K_2SO_4 + 2MnSO_4 + 2H_2SO_4$$

Solution 2004-1:

Aqueous salt solution	Colour of precipitate when NaOH is added in a small quantity	Nature of precipitate(soluble or insoluble) when NaOH is added in excess
Copper (II) sulphate	Blue	Insoluble
Zinc nitrate	White	Soluble
Lead nitrate	White	Soluble
Calcium chloride	White	sparingly soluble
Iron (III) sulphate	Reddish Brown	Insoluble

Solution 2005-1:

1. B and E (Iron (II) sulphate and Magnesium sulphate)
2. C and F (Iron (III) chloride and Zinc chloride)
3. D (Lead nitrate)
4. A (Copper nitrate)
5. F (Zinc chloride)

Solution 2006-1:

Column A	Column B
1. A substance that turns moist starch iodide paper blue.	Chlorine.
2. A compound which releases a reddish brown gas on reaction with concentrated sulphuric acid and copper turnings.	Copper nitrate.
3. A solution of this compound gives a dirty green precipitate with sodium hydroxide.	Ferrous sulphate.
4. A compound which on heating with sodium hydroxide produces a gas which forms dense white fumes with hydrogen chloride.	Ammonium hydroxide.
5. A white solid which gives a yellow residue on heating.	Lead carbonate

Solution 2009-1:
C (Aluminium oxide)

Solution 2009-2:

1. P is Ferric chloride
2. Q is an ammonium salt
3. R is ferrous sulphate

Solution 2009-3:

1. When $BaCl_2$
2. solution is added to the given solution $ZnSO_4$
3. gives a white precipitate while no precipitate is obtained with $ZnCl_2$ solution.
4. When NaOH solution is added to the given solution, iron (II) chloride gives dirty green precipitate while reddish brown precipitate is obtained with iron(III) chloride.