

ANALYSIS OF SALTS

These are special notes prepared in order to demystify the concept of salt as tested in the KCSE examinations. It is our hope that students will find them helpful and will help them to unravel the mystery of salts. However, these notes should be used together with the teachers notes and practical manual notes in demystifying chemistry practical guide book. Also, it is important to that it will be almost impossible to answer any question on salts without knowledge on **solubility of salts**.

Questions on salts will be based on three main areas:

Preparation, Separation, action of heat and other properties eg, hygroscopy, efflorescence, and deliquescence questions on preparation of salts

QUESTIONS ON PREPARATION 1. To answer questions on preparation of salts you need to have solubility of salts on your fingertips. Most questions test on preparation of insoluble salts of which the concept of precipitation must be used. When reacting acid with a base, metal or carbonate you must make sure all the acid is used up by **adding excess metal or excess carbonate to the acid** and always filter to remove the unreacted solid

2. When preparing salts, the method used is determined by starter reagent and if it is soluble, insoluble or a double salt.

3. For soluble salt preparation, add excess reagent to dilute acid, filter, evaporate the filtrate to saturation, cool it to crystallize, filter

4. For insoluble salt the method must involve precipitation by reacting two soluble salt, for

instance: to get the soluble salt whereby the starter reagent is metal/metal oxide/metal hydroxide or metal carbonate. Add excess of the metal/metal oxide or metal carbonate to dilute nitric acid (because all nitrates are soluble), filter then add a soluble salt of sodium or potassium (because all salts of potassium and sodium are soluble) to precipitate the insoluble salt. Filter, wash the residue with distilled water and dry it between filter papers.

5. In case the salt to be prepared is a salt of copper or silver (metals below hydrogen in the reactivity series) first burn the metal in air to form metal oxide (because metals below hydrogen in reactivity series don't react with dilute acids), then add excess metal oxide to dilute acid, filter and add soluble salt of sodium or potassium. filter wash the residue with distilled water and dry it between filter papers.

6. In preparation of insoluble salt whereby you are given the solid soluble salt to use, first dissolve the salt in water to obtain its solution

7. NB when considering insoluble salts remember oxides like CuO, and other metal oxides are insoluble except those of Na and K

Sample question 1

Starting with PbO explain how you can prepare a solid sample of PbSO₄

For the above question refer to guide number 4, first convert PbO to Pb(NO₃)₂, then react with a soluble sulphate of sodium or potassium. Add excess PbO to dilute Nitric (V) acid to form Pb(NO₃)₂, filter to remove unreacted PbO as residue and Pb(NO₃)₂ as filtrate, add Na₂SO₄ to the filtrate to precipitate PbSO₄, filter to obtain PbSO₄ as residue and wash it with distilled water and dry it between filter papers.

Common mistake students make is that they start by reacting lead metal with dilute Sulphuric (VI) acid to form PbSO_4 and reaction by between lead metal and the acid immediately stops due to formation of insoluble coat of PbSO_4 which coats the metal preventing further reaction between the acid and metal, the candidate loses all the marks

Sample question 2

Starting with copper metal describe how you can prepare a solid sample of CuCO_3 , refer to guide number 5.

Heat copper in air to form CuO , add excess CuO to dilute HCl to form CuCl_2 , filter to remove unreacted CuO and CuCl_2 as filtrate, add Na_2CO_3 to the filtrate to precipitate CuCO_3 filter to obtain CuCO_3 as residue wash it with distilled water and dry it between filter papers.

Common mistake students make is that they start by reacting copper metal with dilute acids and copper being below hydrogen in the reactivity series does not react with dilute acids and candidates lose all the marks, such candidates are called as non-starters

Sample question 3

Starting with sodium metal explain how a solid sample of NaHCO_3 can be prepared

Cut a small piece of sodium metal and place in a given amount of distilled water in a beaker with water, it will react to form sodium hydroxide solution. Bubble excess carbon (IV) oxide in sodium hydroxide solution to form sodium hydrogen carbonate. Evaporate sodium hydrogen carbonate solution to saturation and allow it cool for crystals of NaHCO_3 to grow. filter and dry the wet crystals between filter papers

Common mistake .. heat

Sample question 4

Starting with sodium metal explain how a solid sample of NaHSO_3 can be prepared

Cut a small piece of sodium metal and place in a given amount of distilled water in a beaker with water, it will react to form sodium hydroxide solution. Bubble excess sulphur (IV) oxide in sodium hydroxide solution to form sodium hydrogen sulphate solution. Evaporate the resulting solution to saturation and allow it cool for crystals of NaHSO_3 to grow. filter and dry the wet crystals between filter papers

Sample question 5

Describe how a sample of sodium chloride can be prepared in the laboratory by direct Synthesis.

Cut a piece of Sodium: metal, place it on a deflagrating spoon, heat it briefly then lower it into a gas jar of chlorine. It will continue burning forming Sodium Chloride. :

Sample question 6

In preparation of insoluble salt whereby you are given the reagents to use and one of the reagents to be used is a solid soluble salt. First dissolve the soluble salt in distilled water to obtain a solution. See the example below.

a) Describe how the following reagents can be used to prepare Lead sulphate, solid potassium sulphate, solid lead carbonate, dilute nitric acid and distilled water.

dissolve K_2SO_4 in distilled water to obtain K_2SO_4 solution, Add excess PbCO_3 to dilute HNO_3 and stir, filter to obtain $\text{Pb}(\text{NO}_3)_2$ as filtrate,. Mix

$\text{Pb}(\text{NO}_3)_2$ solution with K_2SO_4 solution to precipitate PbSO_4 , filter and wash the residue with distilled water and dry it between filter papers.

Sample question 7

You are provided with the following: - solid lead (II) nitrate, magnesium oxide powder, dilute sulphuric (VI) acid and distilled water. Describe how you can prepare a dry. Sample of lead (II) sulphate

Dissolve lead (II) Nitrate crystals in a given amount of distilled water in a beaker, add excess magnesium $\frac{1}{2}$ oxide powder To dilute sulphuric $\frac{1}{2}$ (vi) acid in a beaker, filter, mix the two solutions obtained, filter wash the residue with distilled water and Dry it between filter papers to obtain a dry sample of lead (II) sulphate.

Sample question 8

Q 8. starting with solid sodium chloride describe how a pure sample of lead (II) chloride can be prepared in the laboratory

Dissolve sodium chloride in distilled water, add aqueous lead (II) nitrate to the sodium chloride solution, filter, the mixture, Wash the residue with distilled water, dry the residue between filter papers.

Sample question 10

Starting with sodium oxide, describe how a sample of crystals of sodium hydrogen carbonate may be prepared Add water to sodium oxide to form sodium hydroxide solution. Bubble excess carbon (IV) oxide in sodium hydroxide solution to form sodium hydrogen carbonate. Heat sodium hydrogen carbonate solution to saturation and allow it to cool to crystallise. filter and dry the crystals between filter papers

Sample question 11

Describe how a solid sample of ZnCl_2 can be prepared starting with 6.5g of Zinc powder and 2M HCl acid. ($\text{Zn} = 65$) Moles of zinc = 0.1 mole
ratio $\text{Zn} : \text{HCl} = 1 : 2$, therefore of HCl should be 0.2 hence you pick 100cm³ of 2MHCl Add 100cm³ of 2M HCl to Zinc and stir the mixture until no more effervescence, heat the contents to saturation, allow it to cool for crystals to form. filter and dry the crystals between filter papers

Sample question 12

Starting with 50cm³ of 0.5M H_2SO_4 describe how you can prepare a sample of Na_2SO_4 crystals, Add 100cm³ of 0.5M NaOH/50cm³ of 1M NaOH to 50cm³ of 0.5M H_2SO_4 in a beaker and shake, evaporate the resulting solution to saturation and allow it to cool for crystals to grow, filter and dry the crystals between filter papers

Question of salts whereby you are given the exact quantity of one the reactants to use, in such question you must invoke the concept of mole concept to get the quantity of the other reactant, in such question you don't need to filter as the reactants react completely and none is in excess. Examples are given below

13. Starting with 50cm³ of 2.8M sodium hydroxide, describe how a sample of pure sodium sulphate crystals can be prepared. Mole ratio $\text{H}_2\text{SO}_4 : \text{NaOH} = 1 : 2$ (3mk)

Add 50cm³ of 1.4 M/ 25cm³ of 2.8M sulphuric (VI) acid to 50cm³ of 2.8M sodium hydroxide Heat $\frac{1}{2}$ the resulting solution to saturation, cool to crystallize, filter $\frac{1}{2}$ and dry crystals between filter papers

Questions on separation Question on separation require candidates to understand properties of salt about their solubility, sublimation and other related substances like metal oxides and substances like sulphur ,iodine etc

To separate a mixture containing soluble and insoluble substance Is such questions assume you want to separate X and Y, X is soluble Y is insoluble The answer format.... Add distilled water to the mixture and stir, X dissolve does not dissolve, filter to obtain Y as residue and solution of X as filtrate,heat the filtrate to saturation and allow it to cool for crystal to form crystals of x. filter, To answer a question on separation involving a soluble and an insoluble salt e.g

Sample question 14

Nb many students lose marks start by dissolve the mixture; This implies that the whole mixture is soluble in water and therefore contradicts the whole separation process. In this case any answer beginning with the word “dissolve’ renders the whole process wrong and therefore candidate losses all the marks. This is called nonstarters

Sample question 15

Some KCl was found to be contaminated with CuO .Describe how a sample of KCl can be obtained from the mixture.

Add distilled water to the mixture and stir, KCl dissolves while CuO does not dissolve,filter to obtain KCl solution as filtrate,evaporate the filtrate to saturation and allow it to cool for crystals to grow. filter and dry the crystals between filter papers

Sample question 16

16. Describe how a mixture of PbCl₂, NaCl and AgCl can be separated to obtain each of the salts

Add cold distilled water to the mixture and stir, NaCl dissolves while PbCl₂ and AgCl do not dissolve, filter to obtain NaCl solution as filtrate , heat the filtrate to dryness to obtain NaCl solid, Add hot distilled water to the remaining mixture in a beaker and stir thoroughly, PbCl₂ dissolves in hot water AgCl does not dissolve, filter while still hot to get AgCl as residue and PbCl₂ solution as filtrate, cool the filtrate to precipitate lead (II) chloride, filter to obtain PbCl₂ as residue and dry it between filter papers

Sample question 17

Given a solid sample of calcium carbonate and lead (II) Chloride ,explain how you can obtain some pure crystals of lead (II) chloride

Add hot distilled water to the mixture in a beaker and stir thoroughly, PbCl₂ dissolves in hot water CaCO₃ does not dissolve, filter while still hot to get PbCl₂ as filtrate, cool the filtrate for to precipitate lead (II) chloride, filter to obtain PbCl₂ as residue and dry it between filter papers

When separating a mixture containing soluble and insoluble salts it is important to note that lead (II) chloride is soluble in hot water hence a mixture containing lead (II) chloride and another insoluble salt can be separated by add hot water to the mixture to dissolve PbCl₂, filter while still hot. see example below

Note : Ammonium chloride undergoes thermal dissociation to form ammonia gas and hydrogen chloride gas which on cooling , the products of heated ammonium chloride recombine together to form the original substance. This process is called thermal dissociation. However, although Ammonium chloride does not sublime when heated, the principle of sublimation can be used to separate a mixture containing ammonium chloride

Sample question 18

A sample of copper turnings was found to be contaminated with copper (II) oxide. Describe how a sample of copper metal can be separated from the mixture

Adds excess dilute hydrochloric acid/ sulphuric (vi) acid CuO reacts with H_2SO_4 while copper metal does not react, Filter to obtain copper metal, Wash with distilled water

To separate a mixture containing substance that sublimates. To answer a question on separation involving a salt that sublimates. Always start your answer in heating the mixture in a container covered with evaporating dish with cold water, where the substance that sublimates will sublime and collect on the evaporating dish. Substances that sublime include FeCl_3 , AlCl_3 , iodine, dry ice, benzoic acid etc

Sample question 19

Given a mixture of lead (II) oxide, iodine and sodium chloride, describe how this mixture can be separated to obtain a sample of each.

Heat the mixture in a container covered with evaporating dish with cold water iodine sublimates and is collected on the evaporating dish. Add water to the remaining mixture, stir and filter. Lead (ii) Oxide remains as residue.

Evaporate the filtrate to dryness to obtain sodium chloride, filter

Nb. Common mistake students don't use a closed container, and also state that iodine sublimates and condenses on cooler parts. Condensing vapour implies that iodine becomes liquid which contradicts the principle of sublimation. This makes the answer wrong and the candidate loses all the marks.

Sample question 26

Describe how CuO , MnO_2 and FeS can be differentiated using dilute HCl only

Place the three substances into separate test-tubes and add dilute HCl. CuO reacts to form a green solution, MnO_2 reacts to form a colourless solution, and FeS reacts to form a green solution

Q27 ; Describe one method that can be used to distinguish between sodium hydrogen carbonate and sodium hydrogen sulphate

Add distilled water to each of the salts , put red and blue litmus papers to each of the solutions ,there will no change on blue litmus paper ,while red litmus paper turns blue when put to the solution of sodium hydrogen

Most students assume that all copper salts are blue in colour ,this is wrong as some copper salts like copper (II) carbonate and copper (II) chloride are green

carbonate, the blue litmus paper turns red and no effect on red litmus when dipped in solution of sodium hydrogen sulphate.

Q28 ; Describe one method that can be used to distinguish between sodium hydrogen carbonate and sodium hydrogen sulphite

Add distilled water to each of the salts, put red and blue litmus to each of the solutions, there will be no change on blue litmus, while red litmus turns blue when put to the solution of sodium hydrogen carbonate, the blue litmus paper turns red and has no effect on red litmus when dipped in solution of sodium hydrogen sulphite.

Q30. ; Describe one method that can be used to distinguish between sodium sulphate and sodium sulphite

Add distilled water to each of the salts, then add acidified barium chloride/barium nitrate, a white precipitate will be formed with sodium sulphite and no precipitate with sodium sulphate.

38. Describe a simple laboratory experiment that can be used to distinguish between sodium sulphide and sodium carbonate. (3mk)

Add dilute hydrochloric acid/HCl/sulphuric(VI) acid/H₂SO₄ to each separately. With sodium sulphide a colourless gas with the smell of rotten eggs is evolved ✓. With sodium carbonate a colourless odourless gas is evolved ✓.

Question on effect on salts on exposure to air, Here the candidates need to understand on meaning of efflorescence, deliquescence and hygroscopy and know examples of salts and substances that undergo the aforementioned processes

Sample question 23

32. Explain why anhydrous NaOH pellets when exposed to air, first turn into a colourless solution and finally into a white powder

NaOH is deliquescent and absorbs water vapour from the atmosphere to form NaOH solution, the NaOH solution reacts with CO₂ to form hydrated sodium carbonate which is efflorescent and loses water to form anhydrous Na₂CO₃ Sample question 24

33. Pellets of NaOH and anhydrous CuSO₄ were put in different petri dishes and left in the open for two hours, explain the observation that was made.

The petri dish containing NaOH had absorbed so much water vapour from the atmosphere to form a solution, petri dish containing CuSO₄ becomes damp and colour changed from white to blue. Reasoning NaOH is deliquescent while CuSO₄ is hygroscopic

34. Explain the observations made when crystals of sodium carbonate decahydrate are left exposed to the atmosphere for two days

i) Crystals turn to a white powder. The salt is efflorescent hence it loses its water of crystallization forming a powder

i. Efflorescent substances (e.g. sodium carbonate decahydrate, copper (II) sulfate pentahydrate) lose some or all of their water of crystallization when exposed to the air.

Common mistake most students make is that they assume that acid salts all acid salts dissolve in water to form acidic solution, this is incorrect as acid salt means the salt has replaceable hydrogen ion, therefore aqueous solution of NaHCO₃ is alkaline not acidic, but aqueous NaHSO₃ and NaHSO₄ are acidic

When preparing Al(OH)₃, or Pb(OH)₂ aqueous NaOH can not be used because the amphoteric Al(OH)₃, or Pb(OH)₂ will dissolve in excess,

hence aqueous ammonia is the suitable alkali to use.

II. Hygroscopic substances (e.g. concentrated sulphuric acid, calcium oxide) absorb water vapour/moisture from the atmosphere but do not dissolve in it. III. deliquescence, the process by which a substance absorbs water vapour from the atmosphere until it dissolves in the absorbed water and forms a solution. Eg of deliquescent substances include calcium chloride, ZnCl_2 , FeCl_3 , MgCl_2 .

Question on action of heat on salt

You must understand the action of heat on carbonates and nitrates, some sulphates like ZnSO_4 , CuSO_4 , FeSO_4 , also note action of heat on $(\text{NH}_4)_2\text{CO}_3$, NH_4NO_3 , $(\text{NH}_4)_2\text{SO}_4$ and NH_4Cl

Nb NH_4Cl undergoes I decomposition on heating to NH_3 and HCl gases, NH_3 is lighter and diffuses faster. Hence the litmus first turns from red to blue, and later the HCl reaches the upper end of test-tube and turns blue litmus red

(i) Explain why it would not be possible to prepare copper sulphate salt by reaction of dilute sulphuric (VI) acid with copper metal?

Copper is below hydrogen in the reactivity series and so cannot displace it from the acid

Q37. Starting with Zinc sulphate solution, describe how a sample of zinc oxide can be obtained from a solution of Zinc (II) Sulphate

Add soluble Sodium carbonate. Filter out the Zinc carbonate. Heat strongly the ZnCO_3 to decompose it to form ZnO . Or heat to evaporate the water to obtain ZnSO_4 solid. Heat ZnSO_4 solid strongly to decompose to form ZnO .

Q41. Starting with solid Aluminium sulphate, describe how a solid sample of Aluminium hydroxide could be prepared. (3mks)

Add distilled water to aluminium sulphate to dissolve. $\frac{1}{2}$ Add aqueous ammonia hydroxide $\frac{1}{2}$ to aluminium sulphate solution, to precipitate Aluminium hydroxide, Filter. $\frac{1}{2}$ Wash the residue with distilled water. Dry it between filter papers $\frac{1}{2}$

Reversed salt preparation. In such questions you might be required to describe how to obtain a metal oxide or a metal from a salt solution, you can heat the salt solution to dryness, then heat the dry salt to decompose to metal oxide, you can also add a soluble carbonate then heat the carbonate strongly. To obtain the metal oxide, to obtain a metal then you can reduce the oxide (while hot) with carbon (II) oxide metal to obtain metal.

common mistake ...many students write absorb water from the atmosphere instead of water vapour/moisture, atmosphere contains water vapour not water

43. Describe how a solid sample of the double salt. Ammonium iron (II) sulphate can be prepared using the following reagents, aqueous ammonia, sulphuric (VI) acid and iron metal

React iron metal with dilute sulphuric (VI) acid to form iron (II) sulphate, react aqueous ammonia with sulphuric (VI) acid to form Ammonium sulphate; mix the two solutions to form a solution of Ammonium iron (II) sulphate; evaporate the solution until crystallization starts, filter to obtain the double salt.

44. Starting with calcium and dilute nitric (V) acid and ammonia describe how a solid sample of calcium ammonium nitrate can be prepared

React calcium metal with dilute nitric (V) acid to form calcium nitrate solution, react aqueous ammonia with nitric (V) acid to form Ammonium nitrate solution; mix the two solutions of calcium nitrate and Ammonium nitrate to form a solution of calcium ammonium nitrate; evaporation the solution until crystallization starts, filter to obtain the double salt

45. Describe how a solid sample of the double salt . Ammonium aluminium (III)sulphate can be prepared using the following reagents, aqueous ammonia ,sulphuric (VI) acid and Aluminium metal

React aluminium metal with dilute sulphuric (vi) acid to form Aluminium (III) sulphate, react aqueous ammonia with sulphuric (VI) acid to form ammonium sulphate;mix the two solutions of Aluminium (iii) sulphate and ammonium sulphate to form a solution of ammonium aluminium(iii)sulphate;evaporation the solution

until crystallization starts,filter to obtain the double salt.

46. Hydrated cobalt (II)chloride exist as pink crystals and anhydrous cobalt (II)chloride is a blue powder. Describe a laboratory experiment that can be used to show that the action of heat on hydrated cobalt(II)chloride is a reversible reaction.(3mk)

Heat the pink hydrated salt in a sealed container. ✓ Pink substance changes to blue. ✓ ½
Collect any vapour and cool it to condense. ✓ ½
Add the condensed liquid to the blue solid. ✓ ½
It turns back to pink. ✓ ½