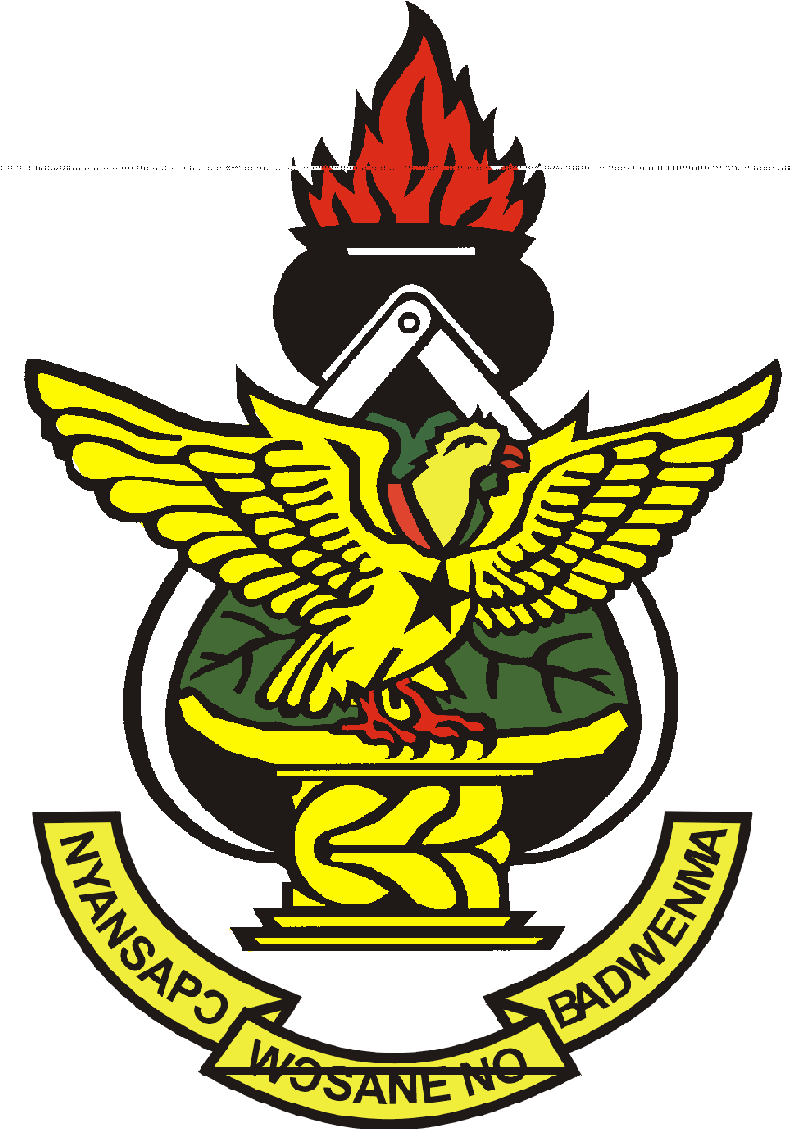
**KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY**

**COLLEGE OF ENGINEERING**

**DEPARTMENT OF CHEMICAL ENGINEERING**

**TITLE: REACTIONS OF ANIONS**

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**COURSE: BSC. CHEMICAL ENGINEERING**

**YEAR: FIRST YEAR**

**EXPERIMENT NO. : I.1.1.1**

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**Aims and Objectives:**

1. To study the reactions of commonly occurring anions.
2. To practice writing balanced equations for these reactions.
3. To use the result of the study to identify unknown anions.

**INTRODUCTION**

Classical qualitative inorganic analysis is a method of [analytical chemistry](http://en.wikipedia.org/wiki/Analytical_chemistry) which seeks to find [elemental](http://en.wikipedia.org/wiki/Chemical_element) composition of inorganic compounds. It is mainly focused on detecting [ions](http://en.wikipedia.org/wiki/Ion) in an [aqueous](http://en.wikipedia.org/wiki/Water) [solution](http://en.wikipedia.org/wiki/Solution), so that materials in other forms may need to be brought into this state before using standard methods. The solution is then treated with various [reagents](http://en.wikipedia.org/wiki/Reagent) to test for [reactions](http://en.wikipedia.org/wiki/Chemical_reaction) characteristic of certain ions, which may cause color change, solid forming and other obviously visible changes. Most of the common anions are colorless in solution, which prevents their identification by direct observation. You can identify them, however, by taking advantage of differences in their chemical behavior.

Anions as negatively charged ions react with cations to form salts. Salts containing the same anions, have equal solubility in water. Based on these facts, seven known and one unknown anion will be provided in the first part of the experiment. The anions will be reacted with silver nitrate solution and since silver nitrate salts have different colours and their solubilites in dilute acid and dilute ammonia are known, they will provide bases for a useful test when identifying the anions. Whiles the test proceeds, observations will be made and recorded to predict their identities. It is worth noting that, most of these reactions are precipitate reactions- they lead to the formation of insoluble products.

Potassium permanganate will be used in the second part of the experiment. It is a powerful oxidizing agent thus, reduced in a reaction. The KMnO4’s oxidation will be carried out in an acidic medium, specifically sulphuric acid because its oxidizing power is higher in acidic medium. The KMnO4 and the H2SO4 will thus be used to identify another batch of anions- five known and one unknown. The solids will be dissolved in water, reacted with KMnO4 and H2SO4. Observations will be made as to whether there will be decolourization of the purple or pink permanganate colour. This done for both known and unknown anions and based on the results, the unknown anions will be identified.

In the third, fourth, fifth and sixth experiment different reagents will be reacted to their respective solutions and as this is being done, observations will be made so as to infer the anions.

**CHEMICALS AND EQUIPMENT**

Test tube

Distilled water

A wash bottle

Brush

Spatula

Oxidizing agent (KMnO4)

Reagents (i.e. AgNO3, H2SO4, NH3,)

Sodium sulphite

Sodium carbonate

Sodium chloride

Potassium iodide

Sodium nitrite

Sodium sulphate

Sodium fluoride

Sodium phosphate

Barium chloride

Calcium chloride

Sulphuric acid

Unknown anions

**PROCEDURE**

**For the reaction of the anions with silver nitrate.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **TEST** | **OBSERVATION** | **EQUATION** | **SOLUBILTY IN HNO3** | **SOLUBILTY IN NH3** |
| KBr + AgNO3 | Insoluble | KBr + AgNO3 → AgBr + KNO3 | Insoluble | Soluble |
| NaCl + AgNO3 | Insoluble | NaCl + AgNO3→ AgCl + NaNO3 | Insoluble | Soluble |
| K2CrO4 + AgNO3 | Insoluble | K2CrO4 + AgNO3 → Ag2CrO4 + KNO3 | Insoluble  Purple colour formation. | Soluble  Yellow colour formation. |
| Na2CO3 + AgNO3 | Insoluble | Na2CO3 + AgNO3→ Ag2CO3 + NaNO3 | Insoluble with effervescence of gas. | Soluble |
| KI + AgNO3 | Insoluble | KI + AgNO3→ AgI + KNO3 | Insoluble | Insoluble |
| Na3PO4 + AgNO3 | Soluble | Na3PO4 + AgNO3→ Ag3PO4 + NaNO3 |  |  |
| NaNO3 + AgNO3 | Insoluble | NaNO3 + AgNO3→ AgNO3 + NaNO3 | Insoluble with effervescence of colourless gas with irritating smell. | Soluble |
| Unknown + AgNO3 | Soluble | Na3PO4 + AgNO3→ Ag3PO4 + NaNO3 |  |  |

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| --- | --- | --- |
| **TEST** | **OBSERVATION** | **EQUATION** |
| KBr + KMnO4 + H2SO4 | Change in colour (purple to light yellow). | 2MnO4- + 10Br- + 16H+→2Mn2+ + Br2+ 8H2O |
| KI + KMnO4 + H2SO4 | Change in colour (purple to light yellow). | 2MnO4- + 10I- + 16H+→2Mn2+ + 5I2+ 8H2O |
| NaNO3 + KMnO4 + H2SO4 | Decolourization occurs.  Effervescence of colourless gas. | MnO4- + 5NO2- + 8H+→Mn2+ + 5NO2+ 4H2O |
| Na2SO3 + KMnO4 + H2SO4 | Decolourization of KMnO4. | 2MnO4- + 5SO32- + 6H+→ 2Mn2+ + 5SO42-+ 3H2O |
| NaCl + KMnO4 + H2SO4 | Decolourization of KMnO4. | 2MnO4- + 10Cl- + 16H+→2Mn2+ + 5Cl2+ 8H2O |
| Unknown + KMnO4 + H2SO4 | Decolourization occurs.  Effervescence of colourless gas. |  |

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| --- | --- | --- |
| **TEST** | **OBSERVATION** | **EQUATION** |
| Na2SO3 + dilute H2SO4 | Effervescence of colourless gas choking gas. | Na2SO3 + H2SO4→ Na2SO4 + H2SO3 |
| Na2CO3 + dilute H2SO4 | Effervescence of colourless gas. | Na2CO3 + H2SO4→ Na2SO4 + H2O+ CO2 |
| KI + dilute H2SO4 | No visible reaction with dilute H2SO4; with conc. H2SO4 effervescence of colourless gas with rotten egg smell. | 2KI + H2SO4→ K2SO4 + I2 + H2S |
| KBr + dilute H2SO4 | No visible reaction with dilute H2SO4; with conc. H2SO4, two liquids formed. Top was colourless and bottom was brown. | KBr + H2SO4→ K2SO4 + H2Br |
| Na2NO3 + dilute H2SO4 | Effervescence of a brown gas. | Na2NO3 + H2SO4→ Na2SO4 + H2O + NO2 |
| Unknown + dil H2SO4 | Effervescence of choking colourless gas. |  |

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| --- | --- | --- |
| **TEST** | **OBSERVATION** | **EQUATION** |
| Na2CO3 + BaCl2 + dilute HCl | White ppt. formed; soluble in dilute HCl. | Ba2+ + CO32-→ BaCO3  BaCO3 + 2HCl→ BaCl2 + H2O+ CO2 |
| Na2SO3 + BaCl2 + dilute HCl | White ppt. formed; soluble in dilute HCl. | Ba2+ + SO32-→ BaSO3  BaSO3 + HCl→ BaCl2 + H2SO3 |
| Na2SO4 + BaCl2 + dilute HCl | White ppt. formed; insoluble in dilute HCl. | Ba2+ + SO42-→ BaSO4  BaSO4 + 2HCl→ BaCl2 + H2S |
| Unknown + BaCl2 + dilute HCl | White ppt. formed; insoluble in dilute HCl. |  |

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| **TEST** | **OBSERVATION** | **EQUATION** |
| NaF + CaCl2 | White ppt. formed; soluble in dilute AgNO3. | 2NaF + CaCl2→ CaF2 + 2NaCl |
| Na3PO4 + CaCl2 | White ppt. formed; insoluble in AgNO3. | 2Na3PO4 + 3CaCl2→ 2Ca3PO4 + 6NaCl |
| Unknown + CaCl2 | White ppt. formed; insoluble in AgNO3. |  |

Unknown 2 = Phosphate ion (PO43-)

Unknown 3 = Nitrate ion (NO3-)

Unknown 4 = Sulphite ion (SO32-)

Unknown 5 = Sulphate ion (SO42-)

Unknown 6 = Fluoride ion (F-)

**POST LAB**

**DISCUSSION**

For the reaction of the anions with silver nitrate, potassium bromide yielded a light cream precipitate which meant silver bromide was formed. Precipitates of silver chloride, silver chromate, silver carbonate, silver iodide and silver phosphate were formed from sodium chloride, potassium chromate, sodium carbonate, potassium iodide and sodium phosphate respectively. The unknown sample containing the unknown anion is a replica of one of the samples in the experiments and as such whatever inference on has for the unknown sample will be tantamount to that of on of the experimented samples. The unknown anion was therefore determined as phosphate ion.

For the reaction of the anions with oxidizing agents, all the anions reacted with the permanganate. This is because chlorides, bromides, iodides, sulphites and some elementary anions are capable of reacting with KMnO4. The colours observed after decolourization of the permanganate are the colours of the anions which were oxidized. Sulphuric acid was instead of any other acid because, HCl can react with potassium permanganate to evolve chlorine, and also HNO3 is an oxidizing agent so it might interfere with the oxidizing action of h KMnO4.

The unknown anion, (unknown 3) decolourized from purple to pale brown. NO2- is pale brown in acidic medium thus, the anion was identified as NO2-  since was oxidized.

MnO4- + 5NO2- + 8H+→Mn2+ + 5NO2+ 4H2O

For the reaction of the anions with sulphuric acid, sodium sulphite yielded hydrogen sulphite gas. Likewise sodium carbonate, sodium chloride, potassium iodide, potassium bromide and sodium nitrate yielded carbon dioxide gas, hydrogen sulphide gas, hydrogen bromide gas and nitrite gas respectively.

The unknown anion, (unknown 4) found to be sulphite ion.

The equation for the unknown sample reaction is:

Na2SO3 + H2SO4→ Na2SO4 + H2SO3

For the action of barium chloride on the anions, sodium carbonate produced a white precipitate (BaCl2) soluble in dilute HCl. The similar inference was made when 1ml barium chloride solution was added to sodium sulphite. But for sodium sulphate and to the unknown samples white precipitates were formed insoluble in dilute HCl. This is so from the solubility rules that salts of carbonates and sulphites are soluble. This includes barium. Again wit reference to literature, salts of sulphates soluble excluding barium.

The unknown anion, (unknown 5) found to be sulphate ion.

The equation for the unknown sample reaction is:

Ba2+ + SO42-→ BaSO4

BaSO4 + 2HCl→ BaCl2 + H2S

For the action of calcium chloride on the anions, sodium fluoride produced a white precipitate (CaF2) soluble in dilute AgNO3 and this again was the same inference for the unknown sample. On the other hand sodium phosphate produced a white precipitate insoluble in AgNO3. The unknown anion, (unknown 6) found to be fluoride ion.

The equation for the unknown sample reaction is:

2NaF + CaCl2→ CaF2 + 2NaCl

**CONCLUSION**

From the aims and objectives stated above and the results obtained it is clear that unknown anions can be identified by reacting their solids with silver nitrate solution, and testing their solubilites in ammonia solution and diluting nitric acid or oxidizing the anions with potassium permanganate in acidic medium.

**PRECAUTIONS**

1. It was ensured that only a small amount of the sample was put into the test tube.
2. It was ensured that all glassware was washed with distilled water before use.

**REFERNECES**

1. Chemistry Laboratory Manual, KNUST, page 33, 34.
2. Introduction to Chemistry by Chopper and Johnson, pages 40-41.
3. Essential Chemistry (Second Edition) – Raymond Chang – pages 150-151, 118.