

Republic of Iraq
Ministry of Higher Education and Scientific Research
Mustansiriyah University
Collage of Science-Department of Chemistry



Practice Qualitative Chemical Analysis

First Grade

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THE PERIODIC TABLE OF THE ELEMENTS

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|--------------------------------------|--|--|--|---|--|--|--|---|---|--|---|--|---------------------------------------|---|---------------------------------------|--|---|---------------------------------------|--|--|---------------------------------------|---|--|---|---|---|--|--|--|--|---|--|--|---|
| 1 IA H Hydrogen 1.008 | 2 IIA He Helium 4.003 | | | | | | | | | | | | | | | | | 13 IIIA B Boron 10.811 | 14 IVA C Carbon 12.011 | 15 VA N Nitrogen 14.007 | 16 VIA O Oxygen 15.999 | 17 VIIA F Fluorine 18.998 | 18 VIIIA Ne Neon 20.180 | | | | | | | | | | | |
| 3 IIIA Li Lithium 6.941 | 4 IIA Be Beryllium 9.012 | 5 IIIB Sc Scandium 44.956 | 6 IVB Ti Titanium 47.88 | 7 VB V Vanadium 50.942 | 8 VIB Cr Chromium 51.996 | 9 VIIB Mn Manganese 54.938 | 10 VIIIB Fe Iron 55.845 | 11 VIIIB Co Cobalt 58.933 | 12 VIIIB Ni Nickel 58.693 | 13 VIIIB Cu Copper 63.546 | 14 VIIIB Zn Zinc 65.38 | 15 IIIB Ga Gallium 69.723 | 16 IIB Ge Germanium 72.61 | 17 IIB As Arsenic 74.922 | 18 IIB Se Selenium 78.972 | 19 IB Br Bromine 79.904 | 20 IIB Kr Krypton 83.80 | | | | | | | | | | | | | | | | | |
| 11 IA Na Sodium 22.990 | 12 IIA Mg Magnesium 24.305 | 13 IIIB Al Aluminum 26.981 | 14 IVB Si Silicon 28.086 | 15 VB P Phosphorus 30.974 | 16 VIB S Sulfur 32.06 | 17 VIIB Cl Chlorine 35.453 | 18 VIIIB Ar Argon 39.948 | 19 IB K Potassium 39.098 | 20 IIB Ca Calcium 40.078 | 21 IIIB Sc Scandium 44.956 | 22 IVB Ti Titanium 47.88 | 23 VB V Vanadium 50.942 | 24 VIB Cr Chromium 51.996 | 25 VIIB Mn Manganese 54.938 | 26 VIIIB Fe Iron 55.845 | 27 VIIIB Co Cobalt 58.933 | 28 VIIIB Ni Nickel 58.693 | 29 VIIIB Cu Copper 63.546 | 30 VIIIB Zn Zinc 65.38 | 31 IIIB Ga Gallium 69.723 | 32 IIB Ge Germanium 72.61 | 33 IIB As Arsenic 74.922 | 34 IIB Se Selenium 78.972 | 35 IB Br Bromine 79.904 | 36 IIB Kr Krypton 83.80 | | | | | | | | | |
| 37 IA Rb Rubidium 85.468 | 38 IIA Sr Strontium 87.62 | 39 IIIB Y Yttrium 88.906 | 40 IVB Zr Zirconium 91.224 | 41 VB Nb Niobium 92.906 | 42 VIB Mo Molybdenum 95.94 | 43 VIIB Tc Technetium 98.906 | 44 VIIIB Ru Ruthenium 101.07 | 45 VIIIB Rh Rhodium 102.905 | 46 VIIIB Pd Palladium 106.367 | 47 VIIIB Ag Silver 107.868 | 48 VIIIB Cd Cadmium 112.411 | 49 IIIB In Indium 114.818 | 50 IIB Sn Tin 118.71 | 51 IIB Sb Antimony 121.757 | 52 IIB Te Tellurium 127.6 | 53 IB I Iodine 126.905 | 54 IIB Xe Xenon 131.29 | 55 IA Cs Cesium 132.905 | 56 IIA Ba Barium 137.327 | 57 IIIB La Lanthanum 138.905 | 58 IIIB Ce Cerium 140.12 | 59 IIIB Pr Praseodymium 140.908 | 60 IIIB Nd Neodymium 144.24 | 61 IIIB Pm Promethium 144.913 | 62 IIIB Sm Samarium 150.36 | 63 IIIB Eu Europium 151.964 | 64 IIIB Gd Gadolinium 157.25 | 65 IIIB Tb Terbium 158.925 | 66 IIIB Dy Dysprosium 162.50 | 67 IIIB Ho Holmium 164.930 | 68 IIIB Er Erbium 167.259 | 69 IIIB Tm Thulium 168.930 | 70 IIIB Yb Ytterbium 173.054 | 71 IIIB Lu Lutetium 174.967 |
| 87 IA Fr Francium 223 | 88 IIA Ra Radium 226 | 89 IIIB Ac Actinium 227 | 90 IIIB Th Thorium 232 | 91 IIIB Pa Protactinium 231 | 92 IIIB U Uranium 238 | 93 IIIB Np Neptunium 237 | 94 IIIB Pu Plutonium 244 | 95 IIIB Am Americium 243 | 96 IIIB Cm Curium 247 | 97 IIIB Bk Berkelium 247 | 98 IIIB Cf Californium 251 | 99 IIIB Es Einsteinium 252 | 100 IIIB Fm Fermium 257 | 101 IIIB Md Mendelevium 258 | 102 IIIB No Nobelium 259 | 103 IIIB Lr Lawrencium 262 | 104 IIIB Rf Rutherfordium 261 | 105 IIIB Db Dubnium 262 | 106 IIIB Sg Seaborgium 266 | 107 IIIB Bh Bohrium 264 | 108 IIIB Hs Hassium 265 | 109 IIIB Mt Meitnerium 268 | 110 IIIB Ds Darmstadtium 271 | 111 IIIB Rg Roentgenium 272 | 112 IIIB Cn Copernicium 285 | 113 IIIB Uut Ununtrium 284 | 114 IIIB Fl Flerovium 289 | 115 IIIB Uup Ununpentium 288 | 116 IIIB Lv Livermorium 293 | 117 IIIB Uus Ununseptium 294 | 118 IIIB Uuo Ununoctium 294 | | | |

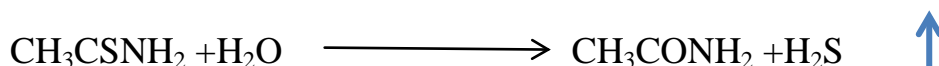
| | | | | | | | | | | | |
|--------------------------|------------------------|---------------------|-----------------------|-------------------------|--------------------|-------------------|-----------------|-----------------|------------------|-------------------|-----------------|
| Lanthanide Series | Actinide Series | Alkali Metal | Alkaline Earth | Transition Metal | Basic Metal | Semi-metal | Nonmetal | Halogens | Noble Gas | Lanthanide | Actinide |
|--------------------------|------------------------|---------------------|-----------------------|-------------------------|--------------------|-------------------|-----------------|-----------------|------------------|-------------------|-----------------|

Experiment no (2)***Separation and analysis of group 2 cations (arsenic- copper group)***

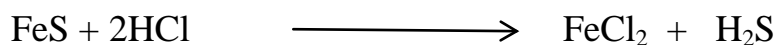
Copper group (Cu^{+2} , Cd^{+2} , Hg^{+2} , Pb^{+2} , Bi^{+3}) IIA

Arsenic group(Sb^{+3} , As^{+3} , Sn^{+4}) IIB

Ions of this group share the possibility of precipitation and separation on the form of sulphides from a solution of 0.3 M for HCl. The H_2S gas is used as a precipitation agent or Aqueous Solution of thioacetamide (CH_3CSNH_3). It will be a source of H_2S gas release. Thioacetamide dissolves easily with water and then aqueous analysis especially when the temperature is higher than the room temperature and according to the equation



There is another way to generate H_2S gas continuously using HCl concentrated in a Kipp device where the reaction can be easily controlled starting or stopping the reaction as soon as the gas faucet is opened and closed, this can be explained according to the equation below:



Precipitation using a thioacetamide solution is much easier and better than using a very toxic H_2S gas. The use of H_2S gas in the precipitation requires the entry of gas in the solution inside the gas cabinet and pay attention to the gas in the solution in order not to lose part of the precipitate solution. Using the thioacetamide solution requires adding enough drops of this solution to (the group or ion) solution to be precipitate and then heating the solution produced inside the test tube in a water bath until the complete precipitate phase. It is important to note here, that not only are the group 2 sulfides are not dissolved in water, but a number of heavy element ions that are precipitated as sulfides, which fall within the five groups in the qualitative analysis. The second group of positive ions (copper-arsenic group) includes eight ions that are precipitate and separated as Sulfides form. Of the HCl acid solution, H_3O^+ concentration in it ranges from 0.2-0.3 M The precipitation factor used is either H_2S or solution thioacetamide (TA). After the precipitation of this group using the above conditions, it will be easy to isolated from

the rest of the subsequent groups (Third, fourth and fifth). Here is a large difference in the solubility product of the large difference between the values of water-constrained constants in the table below. Two groups of sulphides are precipitate in the acidic solution (group 2 ions sulfides) and the other is precipitate from a basic solution.

The following table shows the insoluble sulphides of some positive ions of the second and third groups with the values of the solubility product constants.

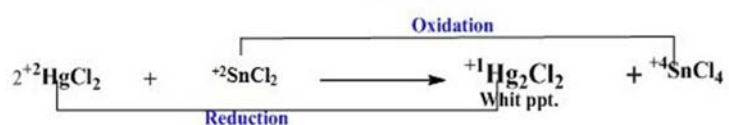
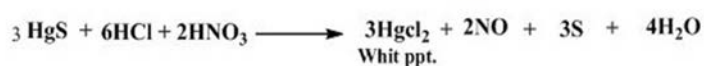
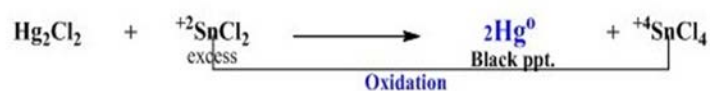
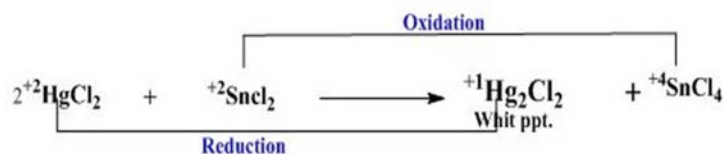
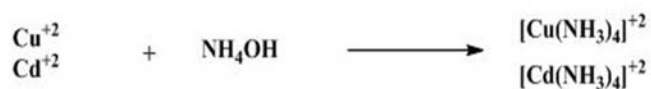
| Ks.p | The sulphide | Ks.p | The sulphide |
|-----------------------|--------------|-----------------------|--------------------------------|
| 1.4×10^{-15} | MnS | 3.6×10^{-29} | CdS |
| 3.7×10^{-19} | FeS | 8.5×10^{-45} | CuS |
| 7.0×10^{-23} | CoS | 3.0×10^{-55} | HgS |
| 1.2×10^{-23} | ZnS | 1.6×10^{-72} | Bi ₂ S ₃ |
| 1.4×10^{-24} | NiS | 1.9×10^{-85} | Sb ₂ S ₃ |

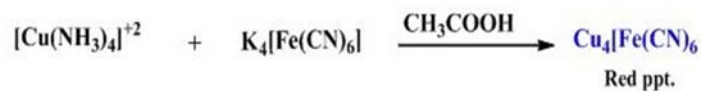
Procedure:

1. We have a mix of group 2 cations (arsenic- copper group). Add 3 drops thioacetamide (TA) solution and 3 drops HNO₃ to a mixture of group 2 cations(arsenic- copper group).
2. Preheat in water bath for about approximately a quarter of an hour until a black Precipitate appears to convert to a brown color by heating.
3. Separate the filtrate(I) from the Precipitate(I).
4. The resulted precipitate (I) consists of(HgS). Therefore, add (Aqua regia) and heated in a water bath with stirring. The precipitate dissolves and we obtain the Hg⁺² ion was obtained. After that, add 3 drops of SnCl₂ solution (reduced agent) until it turns into a black precipitate from Hg⁰ and stop adding it. At the end we have detected the presence of mercury ion (Hg⁺²) in the mix.
5. The filtrate (I) contains these ions(Cu⁺², Cd⁺², Pb⁺², Bi⁺³). Add (3-5) drops of ammonia solution. A white precipitate appears consisting of Bi (OH)₃ and Pb (OH)₂.

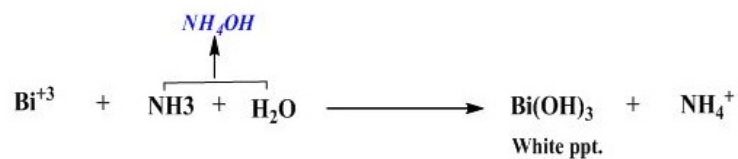
6. Separate the filtrate (II) from the Precipitate (II).
7. Add 2 drops of NaOH solution with stirring to the Precipitate (II) and place it in the centrifuge to obtain a precipitate (III) and filtrate (III).
8. The white precipitate (III) is $\text{Bi}(\text{OH})_3$ added to its sodium stannite reagent and turns into a black color indicating the presence Bi^{+3} ion.
9. **Preparation of sodium stannite reagent** from the reaction of 3 drops of NaOH solution with an increase of SnCl_2 solution until a white precipitate is formed to indicate the formation of sodium stannite reagent.
10. The filtrate (III) Consists of the Na_2PbO_4 , add K_2CrO_4 potassium chromate solution to turn into PbCrO_4 yellow color indicating the presence Pb^{+2} ion.
11. The filtrate (II) contains $\text{Cu}[\text{NH}_3]_4^{+2}$, $[\text{Cd}(\text{NH}_3)_4]^{+2}$ divided it into two parts (AII) and (BII).
12. Add 3 drops from KCN solution to The filtrate)AII (to turn into solution contain of $[\text{Cu}(\text{CN})_4]^{+2}$ and $[\text{Cd}(\text{CN})_4]^{+2}$ add to it 3 drops of thioacetamide (TA) solution and then heat in water bath until a yellow precipitate is formed from CdS compound, indicating the presence Cd^{+2} ion
13. Add 3 drops from acetic acid CH_3COOH solution and 3 drops from Potassium ferrocyanide $\text{K}_4[\text{Fe}(\text{CN})_6]$ solution to The filtrate (BII) to turn into red solution due to the formation of $\text{Cu}_2[\text{Fe}(\text{CN})_6]$ complex indicating the presence Cu^{+2} ion.

EQUATIONS OF SEPARATION AND ANALYSIS OF THE SECOND GROUP II

Detection equations for Hg^{+2} ionEquations of oxidation and reduction of Hg^{+2} ionsInteraction equations $\text{Cu}^{+2}\text{Cd}^{+2}$ with NH_4OH 

Detection equations for Cu^{+2} ion

Interaction equations of complex with KCN

Detection equations for Cd^{+2} ionComposition equations of *Bismuth* hydroxide and *Lead* hydroxide

Preparation equations Na_2SnO_2 

↓
Not: The disappearance of the white ppt. Indication of being Na_2SnO_2

Equation detected ion Bi^{+3} 