

**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	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIII	9 VIII	10 VIII	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1 H 1.008	2 He 4.003	3 Li 6.941	4 Be 9.012	5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.180	11 Na 22.990	12 Mg 24.305	13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.065	17 Cl 35.453	18 Ar 39.948
19 K 39.098	20 Ca 40.078	21 Sc 44.956	22 Ti 47.88	23 V 50.942	24 Cr 51.996	25 Mn 54.938	26 Fe 55.845	27 Co 58.933	28 Ni 58.693	29 Cu 63.546	30 Zn 65.38	31 Ga 69.723	32 Ge 72.61	33 As 74.922	34 Se 78.972	35 Br 79.904	36 Kr 83.80
37 Rb 85.468	38 Sr 87.62	39 Y 88.906	40 Zr 91.224	41 Nb 92.906	42 Mo 95.94	43 Tc 98.906	44 Ru 101.07	45 Rh 102.905	46 Pd 106.368	47 Ag 107.868	48 Cd 112.411	49 In 114.818	50 Sn 118.71	51 Sb 121.757	52 Te 127.6	53 I 126.905	54 Xe 131.29
55 Cs 132.905	56 Ba 137.327	57-103 Lanthanide Series	72 Hf 178.49	73 Ta 180.948	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.222	78 Pt 195.084	79 Au 196.967	80 Hg 200.59	81 Tl 204.383	82 Pb 207.2	83 Bi 208.980	84 Po 209	85 At 210	86 Rn 222
87 Fr 223	88 Ra 226	104 Rf 261	105 Db 262	106 Sg 263	107 Bh 264	108 Hs 265	109 Mt 266	110 Ds 267	111 Rg 268	112 Cn 269	113 Uut 270	114 Fl 271	115 Uup 272	116 Lv 273	117 Uus 274	118 Uuo 276	
Actinide Series		89 Ac 227	90 Th 232	91 Pa 231	92 U 238	93 Np 237	94 Pu 244	95 Am 243	96 Cm 247	97 Bk 247	98 Cf 251	99 Es 252	100 Fm 257	101 Md 258	102 No 259	103 Lr 260	

Alkali Metal	Alkaline Earth	Transition Metal	Basic Metal	Semi-metal	Nonmetal	Halogen	Noble Gas	Lanthanide	Actinide
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## ***Analytical Chemistry & its importance***

The science seeks ever improved means of measuring the chemical composition of natural and artificial materials by using techniques to identify the substances which may be present in a sample and to determine the exact amounts of the identified substance. Analytical chemistry involves the analysis of matter to determine its composition and the quantity of each kind of matter that is present. Analytical chemists detect traces of toxic chemicals in water and air. They also develop methods to analyze human body fluids for drugs, poisons, and levels of medication.

***Analytical chemistry can be classified into:***

**(A) Qualitative analysis** which deals with the identification of elements, ions, or compounds present in a sample (tells us what chemicals are present in a sample).

**(B) Quantitative analysis** which is dealing with the determination of how much of one or more constituents is present (tells how much amounts of chemicals are present in a sample). This analysis can be divided into three main branches:

**(1) Volumetric analysis (Titrimetric analysis):** The analyte reacts with a measured volume of the reagent of known concentration, in a process called titration. **(1<sup>st</sup> grade)**

**(2) Gravimetric analysis:** usually involves the selective separation of the analyte by precipitation, followed by the very non-selective measurement of mass (of the precipitate). **(2<sup>nd</sup> grade)**

**(3) Instrumental analysis:** They are based on the measurement of a physical property of the sample, for example, an electrical property or the absorption of electromagnetic radiation. Examples are spectrophotometry (ultraviolet, visible, or infrared), fluorimetry, atomic spectroscopy (absorption, emission), mass spectrometry, nuclear magnetic resonance spectrometry (NMR), X-ray spectroscopy (absorption, fluorescence). **(4<sup>th</sup> grade)**

## ارشادات مختبرية مهمة

على الطالب قراءة هذه التعليمات والقواعد بدقة والالتزام بها ضماناً لسلامته وسلامة زملائه الطلبة والعاملين معه في المختبر بغية التوصل الى الهدف الاساسي من دخوله المختبر وحصوله على افضل النتائج وأعلى الدرجات وتحقيق الاستفادة الفعلية من وقت الحصة المختبرية راجين من طلبتنا الاعزاء عدم مخالفتها أو الاستهانة بها.

- 1-الالتزام بارتداء الصدرية وذلك حفاظاً على نظافة ملابسك وعدم تلفها وتلوثها بالمحاليل والمواد الكيميائية وارتدائها بداية دخول المختبر.
- 2- وضع الحقائب و الكتب والسجلات التي تخصك في الاماكن المخصصة لها بعيداً عن موقع عملك ولا يكون امامك سوى الملزمة المختبرية ودفتر خاص لتسجيل النتائج والملاحظات الخاصة بالتجربة.
- 3- عدم العبث بالاجهزة والادوات التي لا تحتاجها.
- 4- العناية بالنظافة من الصفات الي يجب أن يتحلى بها كل محلل كيميائي.
- 5- تجنب لمس الجلد أو الانف أو الفم أو العين اثناء العمل الا بعد غسل اليدين بالماء والصابون.
- 6- عند فتح غطاء لقنينة مادة كيميائية يجب ان يوضع الغطاء بشكل مقلوب على المنضدة لضمان عدم تلوته وتلوث المنضدة.
- 7- عدم استعمال ملعقة مادة أو قطارة محلول وادخالها في محلول اخر تجنباً لحدوث تلوث المادة أو المحلول الاخر.
- 8- عند سحب محلول من قنينة أو اخذ مادة صلبة لا يجوز ارجاع الفائض الى نفس القنينة الاصلية انما تخزن في قنينة اخرى أو تهمل.
- 9- عند الوزن يجب استعمال قنينة وزن أو ورق صغير نظيف وجاف واحرص على أن يكون الميزان اقلياً.
- 10- عدم استعمال اي اداة زجاجية قبل تنظيفها جيداً وغسلها بالماء المقطر وتجفيفها.
- 11 - عند سقوط مواد كيميائية على اليد او الملابس يجب غسلها بأكبر كمية من الماء.

## **Qualitative Analysis**

### **Separation of ions to groups and identification**

Identification steps at first time to groups by certain reagent and then detection each ion in group:

- 1- Identification of groups by the certain reagent.
- 2- Identification of each ion in the group by a special reagent.

Properties of reagents used in the detection and separation of ions of different groups from each other:

- 1- Abilities to precipitate ions of group which belong to it from the mixture.
- 2- The reagent must be a pure precipitate with the element ions belonging to its group without ions from another group.
- 3- The resulting precipitate must be easily separated from the other ions in solution
- 4- Reagent must be stable, easily to have it and low cost.

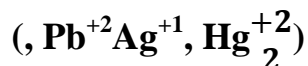
## **Analysis of Cations**

Several methods for analysis of cations for metals were used descriptively.

The cations covered in this course will be restricted will include: to those of silver, lead, mercury, copper, bismuth, cadmium, arsenic, tin, antimony, iron, manganese, cobalt, nickel, zinc, aluminum, chromium, barium, calcium, strontium, magnesium, sodium, potassium, and ammonium.

The outline will describe the method of precipitating and analyzing each group. To analyze a general unknown.

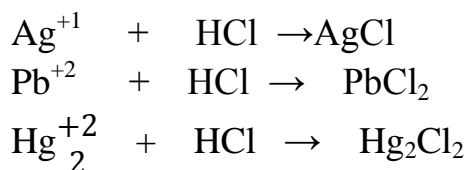
Precipitates of group	Precipitation agent	Ions	Groups
AgCl, Hg <sub>2</sub> Cl <sub>2</sub> , PbCl <sub>2</sub>	3M HCl	Ag <sup>+1</sup> , Pb <sup>+2</sup> , Hg <sub>2</sub> <sup>+2</sup> مجموعة الفضة	Group I
HgS, pbS, Bi <sub>2</sub> S <sub>3</sub> , CuS, CdS  As <sub>2</sub> S <sub>3</sub> , Sb <sub>2</sub> S <sub>3</sub> , SnS <sub>2</sub> , SnS	H <sub>2</sub> S + 0.3M HCl	IIA= (Cu <sup>+2</sup> , Hg <sup>+2</sup> , Pb <sup>+2</sup> , Bi <sup>+3</sup> , Cd <sup>+2</sup> ) مجموعة النحاس  IIB = (As <sup>+3</sup> , Sb <sup>+3</sup> , Sn <sup>+2</sup> , Sn <sup>+4</sup> ) مجموعة الزرنيخ	Group II
Cr(OH) <sub>3</sub> , Al(OH) <sub>3</sub> , Fe(OH) <sub>3</sub>	NH <sub>3</sub> + NH <sub>4</sub> <sup>+1</sup>	IIIA=( Fe <sup>+3</sup> , Cr <sup>+3</sup> ,Al <sup>+3</sup> ) مجموعة الحديد	Group III
MnS, ZnS,NiS,CoS	H <sub>2</sub> S+NH <sub>3</sub> + NH <sub>4</sub> <sup>+1</sup>	IIIB = (Zn <sup>+2</sup> , Mn <sup>+2</sup> , Ni <sup>+2</sup> , Co <sup>+2</sup> ) مجموعة الزنك	
Ba(PO <sub>4</sub> ) <sub>2</sub> , Sr <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> , Ca <sub>3</sub> (PO <sub>4</sub> ) <sub>2</sub> , Mg(NH <sub>4</sub> )PO <sub>4</sub>	(NH <sub>4</sub> ) <sub>2</sub> HPO <sub>4</sub>	Ba <sup>+2</sup> , Sr <sup>+2</sup> , Mg <sup>+2</sup> Ca <sup>+2</sup> , مجموعة الكالسيوم	Group IV
لا يوجد كاشف مرسب خاص بهذه المجموعة حيث أن لكل ايون كاشفه الخاص به		Na <sup>+2</sup> , K <sup>+1</sup> , NH <sup>+1</sup> مجموعة العناصر القلوية	Group V

**Experiment no (1)****Separation and Analysis of First Group**

Group I consists of Silver  $\text{Ag}^{+1}$ , Lead  $\text{Pb}^{+2}$ , and Mercurous (Mercury)  $\text{Hg}_2^{+2}$  and these ions are common of this group.

The chemical characteristics of the metals to be considered in this course shows that the chlorides of the three ions,  $\text{Ag}^{+1}$ ,  $\text{Hg}_2^{+2}$  and  $\text{Pb}^{+2}$  are insoluble whereas those of the other cations are soluble. It is possible, therefore, to separate these three metals from the others in a general unknown by adding  $\text{Cl}^-$  to the solution to precipitate the chlorides of lead, silver, and mercurous.

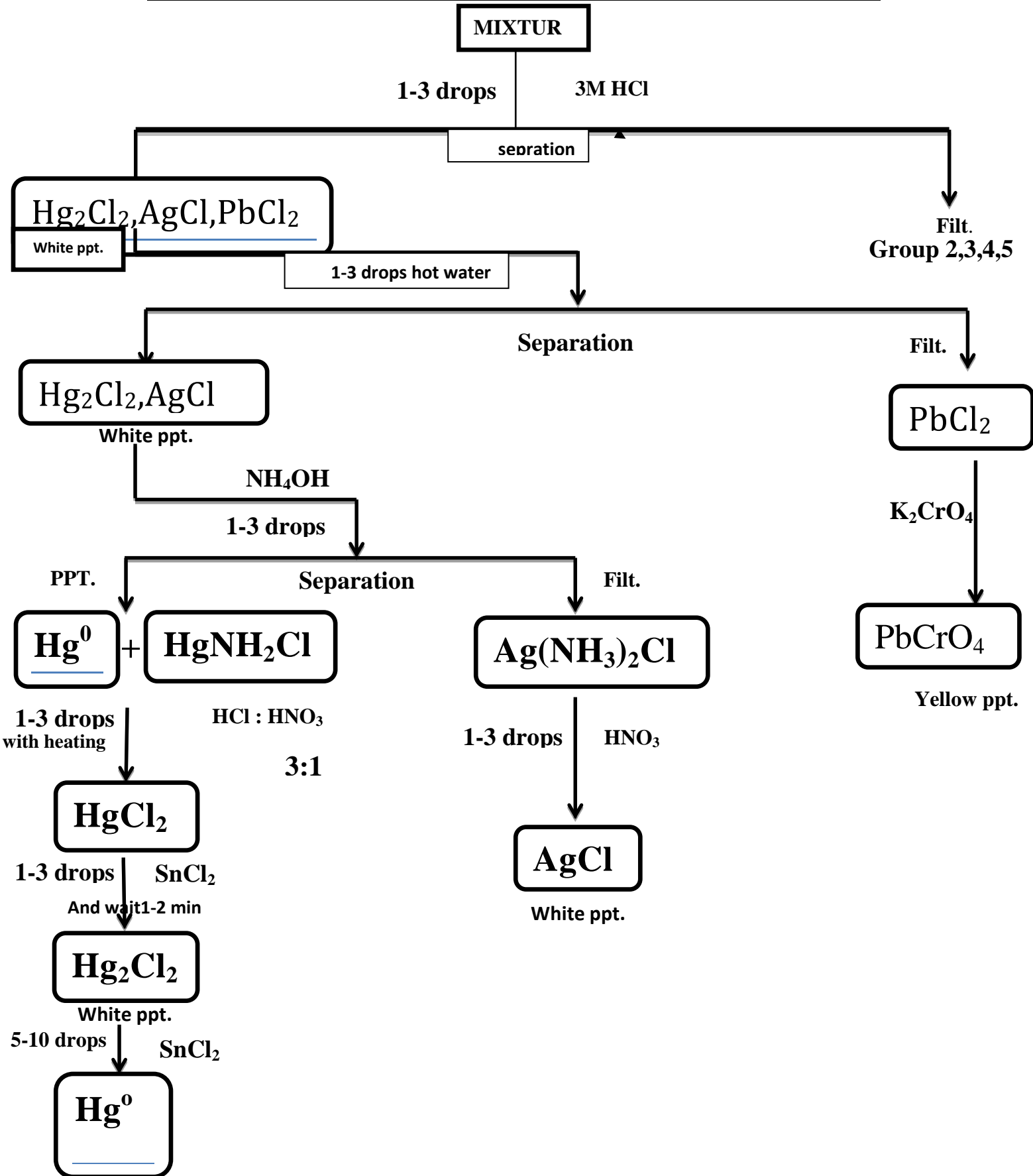
These ions are precipitated by the use of an acid solution of hydrochloric acid at a concentration of (3 M), these precipitations ( $\text{AgCl}$ ,  $\text{PbCl}_2$ , and  $\text{Hg}_2\text{Cl}_2$ ) formed as shown in the equations below:

**Procedure:**

- 1- Transfer 1 ml of the mixture to test tube then add 3 drops of diluted HCl (3M).
- 2- Stir the mixture and put it in the centrifuge (2 min) then separate the filtrate from the precipitate.
- 3- Add to the filtrate 1 drop of diluted HCl.
- 4- The precipitate contains  $\text{AgCl}$ ,  $\text{PbCl}_2$ ,  $\text{Hg}_2\text{Cl}_2$  which are white precipitate.
- 5- Add 1 ml of hot distilled water then transfer to water bath (1-2 min).
- 6- Transfer the test tube to centrifuge while it's hot, separate the filtrate from the precipitate.
- 7- Each ion will be identified by adding the specific reagent:
  - A: Add  $\text{K}_2\text{Cr}_2\text{O}_7$  to hot filtrate while contains  $\text{Pb}^{+2}, \text{Cl}^-$  (yellow ppt.).
  - B: Add  $(\text{NH}_4\text{OH})$  to ppt. then dissolve  $\text{AgCl}$  (black ppt.).
  - C: Add diluted  $\text{HNO}_3$  the precipitate  $\text{AgCl}$ .
  - D: dissolve the ppt. of  $\text{Hg}_2\text{Cl}_2$  in the ( aquaregia ) then add  $\text{SnCl}_2$  (white ppt. ) then change to gray after adding an excess of  $\text{SnCl}_2$ .



SEPARATION AND ANALYSIS OF THE FIRST GROUP I



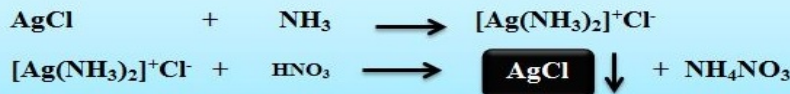


## DETECTION EQUATIONS OF THE FIRST GROUP I



General detection equations

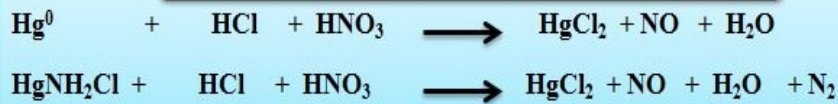
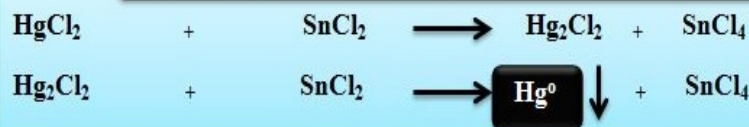
معادلات الكشف العام

Detection equations of Ag<sup>+</sup> ion confirmation معادلات الكشف التأكيد الأيون الفضة

## Addition of ammonia معادلة اضافة الامونيا



## Equation addition of aqua regia معادلة اضافة الماء الملكي

Detection equations of Hg<sub>2</sub><sup>+2</sup> ion confirmation معادلات الكشف التأكيد الأيون Hg<sub>2</sub><sup>+2</sup>Detection equations of Pb<sup>+</sup> ion confirmation معادلات الكشف التأكيد الأيون الرصاص