



Benha university
Faculty of science
Chemistry Department



عملي

Physical chemistry

(CHE125)

المستوى الأول – شعبة رياضيات باللغة الإنجليزية

Notebook

1) Qualitative analysis:

- The identification of constituents of compounds in its simple or complicated form. << What matter is?>>

(2) Quantitative analysis:

- The determination of the actual amount of constituents.

<< How much of it?>>

- (conc, volume, and weight)



- SALT such as NaCl divided into two branches

- 1) Basic radical (cation e.g., Na^+) and Acidic radical (anion e.g., Cl^-)

- The physical properties of any salt:

- 1) Shape; powder, fine crystal, crystal, or sheet.
- 2) Color; colorless, white, yellow..... etc.
- 3) Odor; odor less, pungent odor, has characteristic odor.
- 4) Solubility, soluble or insoluble in water.

- all anions can be classified into 3 groups according to the reagent

- 1) Dilute HCl
- 2) Concentrated H_2SO_4
- 3) Reaction in solution (precipitation)

Dilute hydrochloric acid group (1 gp)

Carbonate (CO_3^{2-}), Bi carbonate (HCO_3^-), Sulphides (S^{2-}), Sulphites (SO_3^{2-}), Thio sulphates ($\text{S}_2\text{O}_3^{2-}$), and Nitrites (NO_2^-)

- All carbonates are insoluble in water except these of the alkali metals and of ammonia
- All bio carbonates are soluble in water
- Dry test reaction
- In dry test tube we put small amount
Of salt and some drops of dil HCl and
Show the observation.



EXP	OBS	RES
Solid salt + dil HCl	Effereence and evolution of CO ₂ gas which turbid lime water due to formation of insoluble CaCO ₃ $\text{Na}_2\text{CO}_3 + 2\text{HCl} \rightarrow 2\text{NaCl} + \text{H}_2\text{O} + \text{CO}_2\uparrow$ $\text{NaHCO}_3 + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O} + \text{CO}_2\uparrow$ $\text{Ca}(\text{OH})_2 + \text{CO}_2 \rightarrow \text{CaCO}_3\downarrow + \text{H}_2\text{O}$	A.R may be carbonate or bicarbonate
Solid salt + dil HCl	Evolution of H ₂ S gas characterized by its rotten odor, blacking of filter paper moistened with lead acetate solution $\text{Na}_2\text{S} + 2\text{HCl} \rightarrow 2\text{NaCl} + \text{H}_2\text{S}\uparrow$ $\text{H}_2\text{S} + \text{Pb}(\text{CH}_3\text{COO})_2 \rightarrow 2\text{CH}_3\text{COOH} + \text{PbS}\downarrow$	A.R may be sulphides
Solid salt + dil HCl	Evolution of SO ₂ gas characterized by its suffocating odor, which turns acidic paper moisten with K ₂ Cr ₂ O ₇ into green $\text{Na}_2\text{SO}_3 + 2\text{HCl} \rightarrow 2\text{NaCl} + \text{H}_2\text{O} + \text{SO}_2\uparrow$ $3\text{SO}_2 + \text{H}_2\text{SO}_4 + \text{K}_2\text{Cr}_2\text{O}_7 \rightarrow \text{K}_2\text{SO}_4 + \text{Cr}_2(\text{so}_4)_3 + \text{H}_2\text{O}$	A.R may be sulphites
Solid salt + dil HCl	Evolution of SO ₂ gas and yellow p.p.t is formed due to separation of sulphur $\text{Na}_2\text{S}_2\text{O}_3 + 2\text{HCl} \rightarrow 2\text{NaCl} + \text{H}_2\text{O} + \text{SO}_2\uparrow + \text{S}\downarrow$	A.R may be thiosulphate
Solid salt + dil HCl	Evolution of colorless gas (nitrous acid) which combines with oxygen of air and giving brown gas (nitrogen di oxide) at the mouth of test tube $\text{NaNO}_2 + \text{HCl} \rightarrow \text{NaCl} + \text{HNO}_2\uparrow$ $3\text{HNO}_2 \rightarrow \text{H}_2\text{O} + \text{HNO}_3 + 2\text{NO}$ $2\text{NO} + \text{O}_2 \rightarrow 2\text{NO}_2$	A.R may be Nitrites
Solid salt + dil HCl	-ve	1 gp is absent

Sure solution

- Put a suitable amount of salt in a test tube, Add small amount of water and shake well If it does not soluble in cold , heat it

EXP	carbonate	Bicarbonate
Salt soln + MgSO ₄ or BaCl ₂	Give dense white p.p.t. on cold $\text{Na}_2\text{CO}_3 + \text{MgSO}_4 \rightarrow \text{Na}_2\text{SO}_4 + \text{MgCO}_3\downarrow$ $\text{Na}_2\text{CO}_3 + \text{BaCl}_2 \rightarrow 2\text{NaCl} + \text{BaCO}_3\downarrow$	Give dense white p.p.t after heating $2\text{NaHCO}_3 + \text{MgSO}_4 \rightarrow \text{Na}_2\text{SO}_4 + \text{Mg}(\text{HCO}_3)_2$ $\text{Mg}(\text{HCO}_3)_2 \rightarrow \text{H}_2\text{O} + \text{CO}_2\uparrow + \text{MgCO}_3\downarrow$ $2\text{NaHCO}_3 + \text{BaCl}_2 \rightarrow 2\text{NaCl} + \text{BaCO}_3\downarrow + \text{H}_2\text{O} + \text{CO}_2$
Salt soln + HgCl ₂	Give reddish brown p.p.t. on cold $\text{Na}_2\text{CO}_3 + \text{HgCl}_2 \rightarrow 2\text{NaCl} + \text{HgCO}_3\downarrow$	Give reddish brown p.p.t after heating $2\text{NaHCO}_3 + \text{HgCl}_2 \rightarrow 2\text{NaCl} + \text{Hg}(\text{HCO}_3)_2\downarrow$ $\text{Hg}(\text{HCO}_3)_2 \rightarrow \text{HgCO}_3\downarrow + \text{CO}_2 + \text{H}_2\text{O}$
Salt soln +AgNO ₃	Give dense white p.p.t. on cold $\text{Na}_2\text{CO}_3 + 2\text{AgNO}_3 \rightarrow 2\text{NaNO}_3 + \text{Ag}_2\text{CO}_3\downarrow$	Give dense white p.p.t after heating $\text{NaHCO}_3 + \text{AgNO}_3 \rightarrow \text{NaNO}_3 + \text{AgHCO}_3$ $2\text{AgHCO}_3 \rightarrow \text{H}_2\text{O} + \text{CO}_2\uparrow + \text{Ag}_2\text{CO}_3$

EXP	SULPHIDES
Salt soln + Pb(CH ₃ COO) ₂	Give black p.p.t $\text{Na}_2\text{S} + \text{Pb}(\text{CH}_3\text{COO})_2 \rightarrow 2\text{CH}_3\text{COONa} + \text{PbS}\downarrow$
Salt soln + AgNO ₃	Give black p.p.t $\text{Na}_2\text{S} + 2\text{AgNO}_3 \rightarrow 2\text{NaNO}_3 + \text{Ag}_2\text{S}\downarrow$

Salt soln + $\text{Na}_2\text{Fe}(\text{CN})_5\text{NO}$	Give violet color $\text{Na}_2\text{S} + \text{Na}_2\text{Fe}(\text{CN})_5\text{NO} \rightarrow \text{Na}_4\text{Fe}(\text{CN})_5\text{NOS} \downarrow$
EXP	SULPHITES
Salt soln + $\text{Pb}(\text{CH}_3\text{COO})_2$	Give white p.p.t $\text{Na}_2\text{SO}_3 + \text{Pb}(\text{CH}_3\text{COO})_2 \rightarrow 2\text{CH}_3\text{COONa} + \text{PbSO}_3 \downarrow$
Salt soln + AgNO_3	Give white p.p.t change to black $\text{Na}_2\text{SO}_3 + 2\text{AgNO}_3 \rightarrow 2\text{NaNO}_3 + \text{Ag}_2\text{SO}_3 \downarrow$
Salt soln + iodine solution	Color of iodine disappears as iodine is reduced to iodine ion $\text{Na}_2\text{SO}_3 + \text{I}_2 + \text{H}_2\text{O} \rightarrow \text{Na}_2\text{SO}_4 + 2\text{HI}$
Salt soln + acidified $\text{K}_2\text{Cr}_2\text{O}_7$	Give green color owing to the formation of chromic sulphate $\text{K}_2\text{Cr}_2\text{O}_7 + 3\text{Na}_2\text{SO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{K}_2\text{SO}_4 + \text{Cr}_2(\text{SO}_4)_3 + \text{H}_2\text{O}$
EXP	THIOSULPHATE
Salt soln + $\text{Pb}(\text{CH}_3\text{COO})_2$	Give white p.p.t change into black by boiling $\text{Na}_2\text{S}_2\text{O}_3 + \text{Pb}(\text{CH}_3\text{COO})_2 \rightarrow 2\text{CH}_3\text{COONa} + \text{PbS}_2\text{O}_3$ $2\text{PbS}_2\text{O}_3 \rightarrow 2\text{SO}_2 + 2\text{PbS} \downarrow$
Salt soln + AgNO_3	Give white p.p.t the color changes through yellow and brown to black $\text{Na}_2\text{S}_2\text{O}_3 + 2\text{AgNO}_3 \rightarrow 2\text{NaNO}_3 + \text{Ag}_2\text{S}_2\text{O}_3$ $\text{Ag}_2\text{S}_2\text{O}_3 + \text{H}_2\text{O} \rightarrow \text{Ag}_2\text{S} \downarrow + \text{H}_2\text{SO}_4$
Salt soln + iodine solution	Color of iodine disappears as iodine is reduced to iodine ion $2\text{Na}_2\text{SO}_3 + \text{I}_2 \rightarrow \text{Na}_2\text{S}_4\text{O}_6 + 2\text{NaI}$
Salt soln + FeCl_3	Give violet color disappear by increase FeCl_3 $2\text{Na}_2\text{S}_2\text{O}_3 + 2\text{FeCl}_3 \rightarrow 4\text{NaCl} + 2\text{Fe}(\text{S}_2\text{O}_3)\text{Cl}$
EXP	NITRITE
Salt soln + $\text{KI} + \text{dil H}_2\text{SO}_4$	Give brown color of iodine as oxidation which give blue color of starch $2\text{KNO}_2 + 2\text{KI} + 2\text{H}_2\text{SO}_4 \rightarrow 2\text{K}_2\text{SO}_4 + 2\text{NO} + \text{I}_2 + 2\text{H}_2\text{O}$

Salt soln + KMnO_4 + dil H_2SO_4	Give purple color of permanganate disappear $5\text{KNO}_2 + 2\text{KMnO}_4 + 3\text{H}_2\text{SO}_4 \rightarrow 5\text{KNO}_3 + \text{K}_2\text{SO}_4 + 2\text{MnSO}_4 + 3\text{H}_2\text{O}$
Salt soln + FeSO_4 + conc H_2SO_4	Give black ring which disappear by shaking or heating tube $2\text{KNO}_2 + 6\text{FeSO}_4 + 4\text{H}_2\text{SO}_4 \rightarrow \text{K}_2\text{SO}_4 + 3\text{Fe}_2(\text{SO}_4)_3 + 4\text{H}_2\text{O} + 2\text{NO}$ $\text{FeSO}_4 + \text{NO} \rightarrow \text{FeSO}_4 \cdot \text{NO}$
Salt soln + AgNO_3	Give white p.p.t $\text{NaNO}_3 + \text{AgNO}_3 \rightarrow \text{NaNO}_3 + \text{AgNO}_2\downarrow$
Salt soln + Zn dust + NaOH	Evolution of ammonia gas $\text{NaNO}_2 + \text{Zn} + 2\text{NaOH} \rightarrow \text{Na}_2\text{ZnO}_2 + \text{NH}_3\uparrow$

Concentrated sulphuric acid group (2gp)

- Chloride (Cl^-), Bromide (Br^-), Iodide (I^-), and Nitrate (NO_3^-)

- Dry test reaction

In dry test tube we put small amount of salt

and some drops of conc H_2SO_4 and Show the observation.



EXP	OBS	RES
Solid salt + conc H ₂ SO ₄	Efferece and evolution of colorless gas (HCl) which forms white clouds when exposed to a glass rod moised with ammonia (NH ₃) OR ammonium hydroxide (NH ₄ OH) $2\text{NaCl} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{HCl}\uparrow$ $\text{HCl} + \text{NH}_3 \rightarrow \text{NH}_4\text{Cl}\downarrow$	A.R may be chloride
Solid salt + conc H ₂ SO ₄	Efferece and evolution of reddish orange fume solved, and solution turns to orange due to separation of bromine $2\text{NaBr} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{HBr}\uparrow$ $2\text{HBr} + \text{H}_2\text{SO}_4 \rightarrow 2\text{H}_2\text{O} + \text{SO}_2 + \text{Br}_2$	A.R may be bromide
Solid salt + conc H ₂ SO ₄	Violet fumed evolved and brown p.p.t or black p.p.t $2\text{KI} + \text{H}_2\text{SO}_4 \rightarrow \text{K}_2\text{SO}_4 + 2\text{HI}\uparrow$ $2\text{HI} + \text{H}_2\text{SO}_4 \rightarrow 2\text{H}_2\text{O} + \text{SO}_2 + \text{I}_2$	A.R may be iodide
Solid salt + conc H ₂ SO ₄	Reddish brown vapor of NO ₂ in the presence of Cu $2\text{KNO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{K}_2\text{SO}_4 + 2\text{HNO}_3$ $4\text{HNO}_3 + \text{Cu} \rightarrow \text{Cu}(\text{HNO}_3)_2 \rightarrow \text{NO}_2 + \text{H}_2\text{O}$	A.R may be nitrate
Solid salt + conc H ₂ SO ₄	-Ve	gp (2) is absent

EXP	CHLORIDES
Salt soln + Pb(CH ₃ COO) ₂	Give dense white p.p.t $2\text{NaCl} + \text{Pb}(\text{CH}_3\text{COO})_2 \rightarrow 2\text{CH}_3\text{COONa} + \text{PbCl}_2\downarrow$
Salt soln + AgNO ₃	Give dense white p.p.t. in soluble in dil HNO ₃ $\text{NaCl} + \text{AgNO}_3 \rightarrow \text{NaNO}_3 + \text{AgCl}\downarrow$
Salt soln + Hg ₂ (NO ₃) ₂	White p.p.t $\text{Hg}_2(\text{NO}_3)_2 + 2\text{NaCl} \rightarrow 2\text{NaCl} + \text{Hg}_2\text{Cl}_2\downarrow$

EXP	BROMIDES
Salt soln + Pb(CH ₃ COO) ₂	Give white p.p.t $2\text{NaBr} + \text{Pb}(\text{CH}_3\text{COO})_2 \rightarrow 2\text{CH}_3\text{COONa} + \text{PbBr}_2\downarrow$
Salt soln + AgNO ₃	Give pale yellow p.p.t. soluble in dil HNO ₃ $\text{NaBr} + \text{AgNO}_3 \rightarrow \text{NaNO}_3 + \text{AgBr} \downarrow$
EXP	IODIDES
Salt soln + Pb(CH ₃ COO) ₂	Give yellow p.p.t $2\text{NaI} + \text{Pb}(\text{CH}_3\text{COO})_2 \rightarrow 2\text{CH}_3\text{COONa} + \text{PbI}_2 \downarrow$
Salt soln + AgNO ₃	Give cancer yellow p.p.t $\text{NaI} + \text{AgNO}_3 \rightarrow \text{NaNO}_3 + \text{AgI} \downarrow$
Salt soln + Hg ₂ (NO ₃) ₂	Give reddish brown p.p.t disappear by increasing of solution $2\text{KI} + \text{HgCl}_2 \rightarrow 2\text{KCl} + \text{HgI}_2\downarrow$ $2\text{KI} + \text{HgI}_2 \rightarrow \text{K}_2\text{HgI}_4$
EXP	NITRATE
Salt soln + freshly prepared FeSO ₄ + 2drops of conc H ₂ SO ₄	Give brown or black ring disappear by shacking the solution $2\text{KNO}_3 + 6\text{FeSO}_4 + 4\text{H}_2\text{SO}_4 \rightarrow \text{K}_2\text{SO}_4 + 3\text{Fe}(\text{SO}_4)_3 + 2\text{NO} + \text{H}_2\text{O}$ $\text{FeSO}_4 + \text{NO} \rightarrow \text{FeSO}_4.\text{NO}$
Salt soln + Zn dust + NaOH	Give odor of ammonia $\text{NaNO}_3 + 4\text{Zn} + 7\text{NaOH} \rightarrow 4\text{Na}_2\text{ZnO}_2 + 2\text{H}_2\text{O} + \text{NH}_3\uparrow$

GROUP (3)

- Sulphate (SO₄²⁻), Phosphate (PO₄³⁻), and Borate (B₄O₇²⁻)
- Prepare a conc solution of salt and add BaCl₂, this gives white p.p.t and according to the solubility of this precipitate in dil HCl or excess of BaCl₂ we can predict the acidic radical as

ACIDIC RADICAL	Dil HCl	Excess BaCl₂
Sulphate	Insoluble	In soluble
Phosphate	Soluble	In soluble
borate	soluble	Soluble

- $\text{Na}_2\text{SO}_4 + \text{BaCl}_2 \rightarrow 2\text{NaCl} + \text{BaSO}_4\downarrow$
- $\text{Na}_2\text{HPO}_4 + \text{BaCl}_2 \rightarrow 2\text{NaCl} + \text{BaHPO}_4\downarrow$
- $\text{Na}_2\text{B}_4\text{O}_7 + \text{BaCl}_2 \rightarrow 2\text{NaCl} + \text{Ba}(\text{BO}_3)_2\downarrow + 2\text{H}_3\text{BO}_3$

- **Conformal tests for group (3)**

EXP	SULPHATE	PHOSPHATE	BORATE
Salt soln + $\text{Pb}(\text{CH}_3\text{COO})_2$	Give white p.p.t $\text{Na}_2\text{SO}_4 + \text{Pb}(\text{CH}_3\text{COO})_2 \rightarrow 2\text{CH}_3\text{COONa} + \text{PbSO}_4\downarrow$	-ve	-Ve
Salt soln + AgNO_3	Give white p.p.t not affect by heating $\text{Na}_2\text{SO}_4 + 2\text{AgNO}_3 \rightarrow 2\text{NaNO}_3 + \text{Ag}_2\text{SO}_4\downarrow$	Give yellow p.p.t $\text{Na}_3\text{PO}_4 + 3\text{AgNO}_3 \rightarrow 3\text{NaNO}_3 + \text{Ag}_3\text{PO}_4\downarrow$	Give white p.p.t change into brown by heating $\text{Na}_2\text{B}_4\text{O}_7 + 2\text{AgNO}_3 + 3\text{H}_2\text{O} \rightarrow 2\text{NaNO}_3 + 2\text{H}_3\text{BO}_3 + 2\text{AgBO}_2\downarrow$ $2\text{AgBO}_2 + 3\text{H}_2\text{O} \rightarrow 2\text{H}_3\text{BO}_3 + \text{Ag}_2\text{O}$
Salt soln + HgCl_2	-Ve	-ve	Reddish brown p.p.t soluble in dil HCl $\text{HgCl}_2 + \text{Na}_2\text{B}_4\text{O}_7 \rightarrow 2\text{NaCl} + \text{Hg}(\text{BO}_2)_2\downarrow + \text{B}_2\text{O}_3$