

Application of solubility product principle and common ion effect

Common ion effect ~~increases~~ ^{decreases} the ionic product but does not change the value of solubility product constant of sparingly soluble salt. This effect plays role in controlling pH of solution and determines solubility of salt.

Similarly solubility product principle helps to predict whether a solution gives ppt or not. This is useful in the following applications.

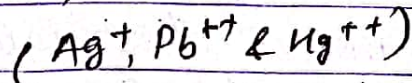
App

Applications:

1. Application in qualitative analysis.

The common ion effect and solubility product principle is useful in Group separation of basic radicals in qualitative salt analysis, on the basis of ~~precipitation~~ the cations precipitation. such as,

exa




- Group (I) cations, precipitated as their chlorides.
- Group II cations (Hg^{++} , Pb^{++} , Cu^{++} , Sb^{++}) precipitated as their sulphides on passing H_2S gas.
- Group (III) cations (Fe^{++} , Al^{++} , and Cr^{++})

please
Understand by proper Generalization.

precipitated as their hydroxides on the addition of NH_4Cl and NH_4OH to the given salt solution.
→ Group (IV) metal cations (Zn^{++} , Mn^{++} , Ni^{++} & Co^{++}) precipitated as ~~their~~ their sulphides on passing H_2S to the salt solution containing NH_4Cl and NH_4OH .

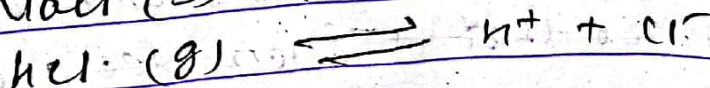
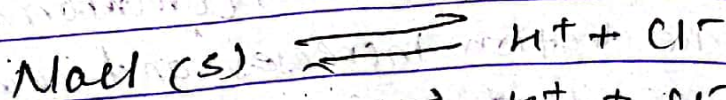
117 Application in quantitative (Gravimetric) estimation.

~~On~~ The sparingly soluble salt like AgCl , CaF_2 , BaSO_4 etc of gravimetric estimation, ~~an~~ the excess of suitable precipitating agent used.

 E.g. The precipitation of BaSO_4 can be made by addition of H_2SO_4 . Here, presence of excess ~~so~~ common ion SO_4^{--} causes the increase in ionic product of $(\text{Ba}^{++}) (\text{SO}_4^{--})$ which is higher than the solubility of BaSO_4 . Thus BaSO_4 get precipitated and filtered out.

III> Purification of common salt:

The impure salt can be pure by passing HCl gas in saturated solution of NaCl .



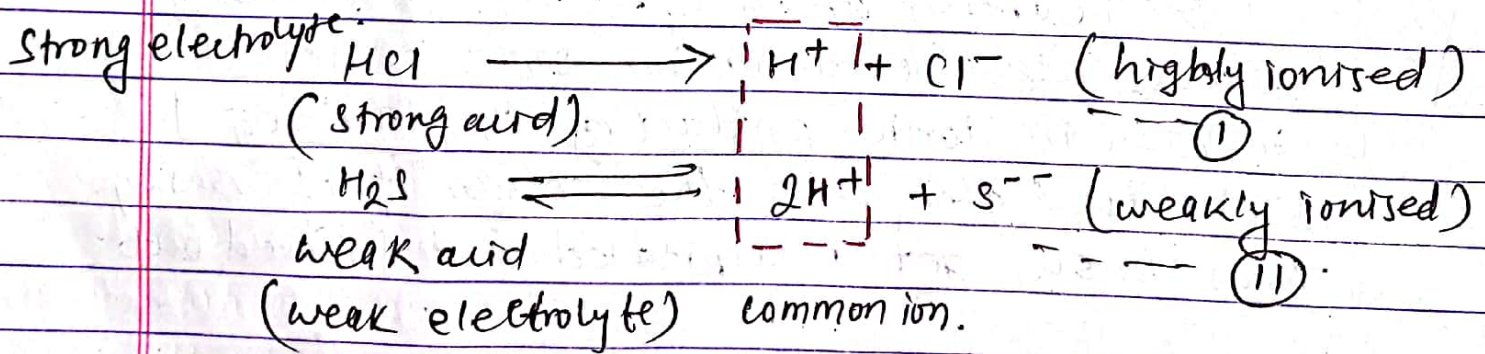
Here common ion Cl^- helps to increase the ionic product $[\text{Na}^+][\text{Cl}^-]$ in such that exceeds the solubility product of NaCl . hence pure NaCl precipitated & all impurities remain in the solution.

V.V.I. In detail:

Role of HCl in the qualitative analysis of Group II basic radicals (Ca)

Group (II) cation Ag^{++} , Pb^{++} and Hg_2^{++} precipitated as their sulphides (metal sulphides) by passing HCl in the presence of dil. HCl .

The dissociation take place as,



The presence of HCl suppresses the degree of ionization of H_2S by common ion effect.

On addition of HCl in the solution of salts HCl ionizes. as $[\text{H}^+]$ common ion. so the $[\text{H}^+]$ concentration increases and combined with S^{--} ion. so that S^{--} ion dec and formed

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more H_2S . So that the rxn (11) shift to the backward. The concentration of S^{2-} ion in the solution decreases due to common ion effect. As a result, the ionic product of metal sulphide of group II exceeds their corresponding solubility product.

i.e. $I.P > K_{sp}$.

Hence the metal sulphide of group II get precipitated leaving behind the metal sulphide of other group basic radicals.

i.e. Group III B cations.

It is because the solubility product of Group II cations is lesser than Group III B.

It means the Group II

cations precipitate even

In lower concentration of S^{2-} ion than Group III B.

i.e. very low

concentration of S^{2-} ion is sufficient to react with Group II radicals, so they precipitate.

and other group cations remain in the solution.

If HCl is not added, S^{2-} ion concentration increases, so Group III also precipitate.

i.e.

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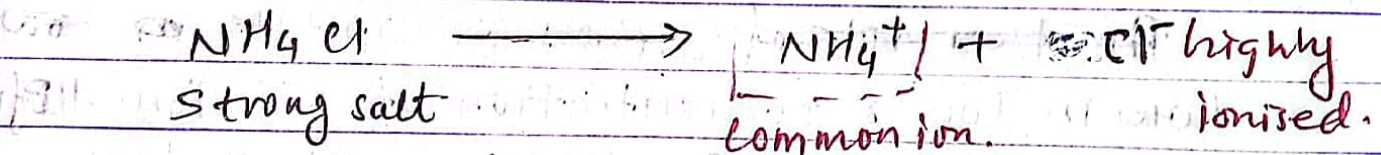
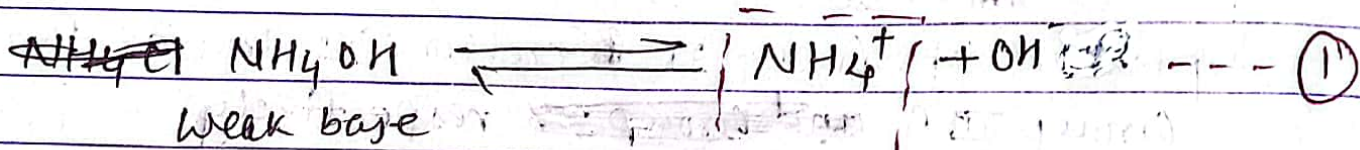
Role of NH_4Cl in the qualitative analysis of Group IIIA Metals.

For ~~only~~ the separation of Group IIIA like Fe^{3+} , Al^{3+} etc the group reagent is $\text{NH}_4\text{Cl} + \text{NH}_4\text{OH}$

Suppose the solution contains Group IIIA cations and Group V cations, then ~~the~~ the IIIA cations.

is separated by precipitation of their hydroxides by adding group reagent NH_4Cl and NH_4OH . Group V also precipitate as their hydroxide but in higher concentration of $[\text{OH}^-]$ ions.

NH_4Cl and NH_4OH are added to the given salt solution. Then the ionization takes place as,



When NH_4Cl is added along with NH_4OH , the concentration of OH^- in eqn (1) decreases. due to increase in concentration of common ion NH_4^+ . so that NH_4^+ ion reunite with OH^- ion in eqn (1) and forms NH_4OH . i.e. the concentration of $[\text{OH}^-]$ ion decreases. Hence.

the reaction shifts to the left (backward) in eqn (1)

~~The The group V hence here the The~~

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~~reduced~~ concentration

Concentration OH^- ion get reduced to that extent that the solubility product of Group IIIA hydroxides ($\text{Fe}(\text{OH})_3$, $\text{Al}(\text{OH})_3$) only becomes less than ~~that~~ their ionic product. & hence only Group IIIA hydroxides get precipitate.

The solubility product of Group IIIA is less than the solubility product of Group V ~~hydro~~ metal hydroxides. so that, very low concentration of OH^- ions from NH_4OH can form their hydroxides. ~~so easily precipitate than Group V.~~ so, and precipitate first.

If OH^- ion concentration is increases. the Group V ~~metal~~ metal form ~~hydro~~ their hydroxides. so Group IIIA ^{also} cannot be separated.

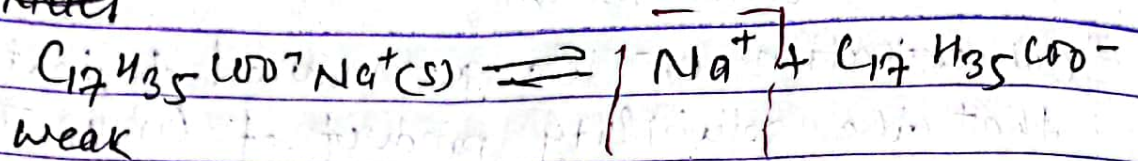
Thus. The ~~role~~ role of NH_4Cl is along with NH_4OH is ~~to~~ to decrease the ~~concentrati~~ concentration of OH^- ion & due to common ion effect.

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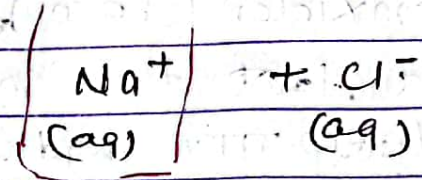
(*) Precipitation of soap. (another application of solubility product and common ion effect).

To prepare soap, NaCl is added to the boiling solution of soap (sodium salt of fatty acid). The NaCl has common ion Na^+ with soap. ($\text{C}_{17}\text{H}_{35}\text{COONa}$)

NaCl



NaCl



Due to increase in Na^+ ion concentration at the ionic product of soap exceeds the solubility product constant (K_{sp}). Thus, soap is precipitated. Then it is separated out from the solution.

The role of NaCl is to decrease the concentration of $\text{C}_{17}\text{H}_{35}\text{COO}^-$ due to common ion effect.