Solubility

pH and Solubility

- This is primarily LeChâtelier's principle
- If a compound contains the conjugate base of a weak acid, addition of H_3O^+ from a strong acid will increase the compound's solubility.
- Predict the Effect on Solubility
- Write balanced equations and explain how addition of HNO_3 will affect the solubility of:
- **a)** calcium fluoride
- **b)** zinc acetate
- **c)** silver iodide.

Predicting the Formation of a Precipitate: K_{sp} vs. Q_{sp}

- Dissociation equations
- **Solid (precipitate) ⇌ Dissolved**
- If $K_{sp} = Q_{sp}$, then the solution is saturated and no change occurs.
- If $K_{sp} < Q_{sp}$, then a precipitate forms until the solution is saturated.
- If $K_{sp} > Q_{sp}$, then the solution is unsaturated and no precipitate forms.

Predicting Whether a Precipitate Will Form

- Phosphate in natural waters often precipitates as insoluble salts, such as $Ca_3(PO_4)_2$.
- In a certain river, $[Ca^{2+}]_{init}$ =2.0 x 10^{-8} M. and $[PO_4^{3-}]_{init}$ = 1.0 x 10^{-9} M.
- Will $Ca_3(PO_4)_2$ precipitate?
- K_{sp} of $Ca_3(PO_4)_2$ = 1.2 x 10^{-29}.

Selective Precipitation

- *Selective precipitation* is a technique to separate metal ions from a solution with multiple ions present.
- A reagent whose anion forms a precipitate with either one or a few metal ions in the mixture will precipitate certain metals out of solution and leave the others.
- So a solution of Ca^{2+} K^+, can be separated by adding a CO_3^{2-} ion because this will form a precipitate with calcium

Problem

- A solution contains 1.0 x10^{-4} M Cu^+ and 2.0 x10^{-3} M Pb^{2+}. If a source of I^- is added gradually to this solution, will PbI_2 (K_{sp} = 1.4 x10^{-8}) or CuI (K_{sp} = 5.3 x10^{-12}) precipitate first?
- Specify the concentration of I^- necessary to begin precipitation of each salt.

Coordination Complex

AP Test

- These questions used to always be in the equation prediction section that has been removed.

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(b) Excess hydrochloric acid is added to a solution of cobalt(II) nitrate to produce a coordination complex.

(i) Balanced equation:

(ii) Which species in the reaction acts as a Lewis base?

AP Learning Objectives

- Lewis acid-base concepts are **beyond the scope** of this course and the AP Exam.
- **Rationale:** The definition of Lewis acids is commonly taught in a first-year high school chemistry course and is therefore considered prior knowledge. *Note:* ***The formation of complex ions and the qualitative impact on solubility are both part of the AP Chemistry course.***

Coordination Compound/ Complex ion

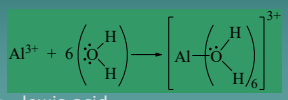
- Transition metals form complex ions or coordination complexes with ligands.
- A ligand is a Lewis base, electron pair donor.
- When these complex ions are in a neutral compound it is called a coordination compound
- These tend to be colorful.

Lewis Acids and Bases

- This is the broadest definition.
- An *acid* is an **electron pair** acceptor.
- A *base* is an **electron pair** donor.
- It is easy to remember that Lewis acids and bases are electron pair donor or acceptors because Lewis is famous for electron dot notation.

Lewis Acids and Bases

- Lewis acid: electron pair *acceptor*
- Lewis base: electron pair *donor*



Al^{3+} lewis acid
H_2O lewis base

Complex ion reactions

- Formation of complex ions
- Common complex ions metals
- Fe Co Ni Cr Cu Zn Ag Al
- Common ligands
- NH_3 F^- Cl^- I^- Br^- CN^- OH^- SCN^-
- **General rule: the number of ligands will be twice the charge of the metal ion**

Example

- Iron (III) nitrate reacts with potassium cyanide to form a complex ion.
- $Fe^{3+} + 6\ CN^- \rightarrow Fe(CN)_6^{3-}$
- How did I get the charge?
- Iron is 3+ , 6 cyanides at 1-

This is how they used to grade it

(b) Excess hydrochloric acid is added to a solution of cobalt(II) nitrate to produce a coordination complex.

(i) $Co^{2+} + 4\ Cl^- \rightarrow [CoCl_4]^{2-}$ Note: any number of coordinated Cl^- ions from 1 to 6 is acceptable.	2 points are earned for the correct reactants. 1 point is earned for the correct product. 1 point is earned for correctly balancing the equation for both mass and charge.

(ii) Which species in the reaction acts as a Lewis base?

Cl^- functions as a Lewis base.	1 point is earned for the correct identification of the Lewis base.

Examples

- Zinc (II) sulfate reacts with sodium thiocyanate
- Concentrated ammonia is reacted with cobalt (III) chlorate
- Barium hydroxide reacts with nickel (II) nitrate

Complex ions and solubility

- Ionic compounds that have a very low solubility can be dissolved if they form coordination complexes.
- AgCl is not very soluble. $K_{sp} = 1.6 \times 10^{-10}$
- That means the solubility or concentration when the solution is saturated in 1.3×10^{-5} M.

Complex ion

- However, silver readily forms a complex ion.
- $Ag^+ + 2\ NH_3 \rightarrow Ag(NH_3)_2^+$
- This complex ion is much more soluble with chloride.
- The solubility of silver chloride in 10 M NH_3 is .48 M
- So much more silver chloride will dissolve in an ammonia solution, than will in a water solution.