THE PRECIPITATION BEHAVIOR OF GROUP IIB CATIONS WITH OXYANIONS OF SELENIUM AND TELLURIUM

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SUMMARY

The compositions and aqueous solubilities at room temperature of the tellurites, tellurates, selenites and selenates of zinc, cadmium and mercury have been investigated. The techniques employed include pH and indicator-electrode titration and quantitative chemical analysis of filtrates. Substantial solubility was found for the tellurates and selenites of zinc and cadmium. Zinc, cadmium and mercuric mercury are all precipitated as the orthotellurates, $M_2H_2TeO_6$. The selenates of mercury are sparingly soluble and basic in nature; zinc and cadmium selenates are readily soluble. The tellurites of zinc, cadmium and mercury contain excess TeO_2 when precipitated from acid solutions.

INTRODUCTION

The selenides and tellurides of zinc, cadmium and mercury are finding use as semiconducting materials. It is conceivable that during the course of etching treatments, species containing oxidized forms of selenium or tellurium could be precipitated or form insoluble films on the semiconductor substrate. Since the literature concerning the compounds of Group IIB cations with oxyanions of selenium and tellurium is incomplete, it was thought that a comprehensive investigation of the solubilities of these compounds would be worthwhile.

Accordingly, pH-solubility relationships at room temperature were investigated for the selenites, selenates, tellurites and tellurates of zinc, cadmium and mercury. The approximate precipitate compositions were arrived at by qualitative precipitation tests (defined subsequently) and by pH, conductivity and polarizedelectrode titrations. Attempts to find precipitation end points using indicator electrodes of the appropriate Group IIB metals were less successful. The solubilities and more exact compositions of the precipitated species were determined by quantitative analysis of the filtrates.

In a number of instances the precipitates formed on mixing equivalent quantities of the starting solutions contained a coprecipitated compound. In such cases, one or the other component of the filtrate was found to be in excess, and its concentration was taken as the basis for the calculation of solubility. In all cases, including formation of ill-defined basic compounds, where ambiguity might result, the concentrations of both components of the filtrate are given.

EXPERIMENTAL

The metal solutions were standardized by colorimetric titration using EDTA. The selenium and tellurium solutions were standardized by reduction to the element, followed by weighing. For determining the solubilities and the compositions of the precipitates, known volumes of standard solutions were mixed. The filtrates were analyzed for both cation and anion photometrically. Mercury¹ and cadmium² were determined with dithizone, Hg(I) being first oxidized to Hg(II) with concentrated nitric acid. Zinc was determined by atomic-absorption spectrophotometry. Selenite³ was determined using 3,3'-diaminobenzidene; selenate had first to be reduced to selenite by evaporation to a small volume with concentrated hydrochloric acid. Tellurite⁴ was determined using s-diphenylthiourea; tellurate had first to be reduced to tellurite with concentrated hydrochloric acid. In determining tellurate by this method, it was found that sufficient time must be allowed for complete reduction to tellurite.

The sodium or potassium selenite, tellurite and tellurate (but not selenate) stock solutions were distinctly alkaline as a consequence of anion hydrolysis. For three of the four anions studied, therefore, the course of the precipitation could be conveniently followed by measurement of the pH. A Leeds & Northrup pH meter was used for pH titrations. Comparable results were obtained employing a glass electrode or a cathodically-polarized platinum electrode, which behaves to some degree as a hydrogen electrode⁵. Conductivity titrations were performed with a Radiometer conductance bridge.

RESULTS

1. The tellurites of zinc, cadmium and mercury

Zinc and cadmium tellurites

Bulky white precipitates were formed on mixing zinc or cadmium solutions with potassium tellurite solution. The solubility of the precipitates increased with the acidity of the solution. Appreciable solubility $(\geq 0.02 M)$ was observed below pH 1.4. In strongly alkaline solution (I N NaOH), the zinc salt dissolved and the cadmium salt was converted to gelatinous cadmium hydroxide.

The pH was followed during titration of 0.02 M metal solution and 0.05 M K₂TeO₃ (Fig. 1). The end point is established by the appearance of hydroxyl ion derived from hydrolysis of tellurite ion and signifies the removal of metal ion as tellurite or hydroxide. The most abrupt change in pH occurred at an equivalence point of $I \ Cd^{2+}$ (or Zn^{2+}): $I \ TeO_3^{2-}$. These compositions agree with experiments (hereafter called "precipitation tests") in which known volumes of the two solutions were mixed and the filtrates tested for excess of either ion by addition of the other. End points of conductivity and polarized electrode titrations also indicated precipitation of the compounds $ZnTeO_3$ and $CdTeO_3$.

Analysis of filtrates at the pH of the end point, 7.5, revealed the concentration of the metal ion to be lower than that of total tellurite, a circumstance ascribable to

coprecipitation of metal hydroxide. The pertinent concentrations, in g-ion/liter, are: $[Zn^{2+}] = 6.34 \times 10^{-5}$, $[TeO_3^{2-}] = 9.71 \times 10^{-4}$ and $[Cd^{2+}] = 5.76 \times 10^{-6}$, $[TeO_3^{2-}] = 6.88 \times 10^{-4}$.

As shown in Fig. 1, titration of $0.02 M \text{ Cd}(\text{NO}_3)_2$ in $0.01 M \text{ HNO}_3$ gave an end point different from that obtained with unacidified solution, since an additional volume of tellurite solution was needed for neutralization of the nitric acid. When $0.01 M \text{ HNO}_3$ was similarly titrated, a white precipitate (probably TeO₂) appeared, subsequently redissolving in excess potassium tellurite (pH > 9).



Fig. 1. pH titration curves for tellurites.

From precipitation tests it was found that the composition of the precipitate varied with the acidity of the cadmium solution. Precipitates from initially more acid solutions contained a larger proportion of TeO_2 . It thus appears that $CdTeO_3$ and TeO_2 (or tellurous acid) are coprecipitated from acid solutions of cadmium nitrate. The equilibria involved may be represented as follows:

$$\begin{array}{ccccc} \mathrm{TeO}(\mathrm{OH})^+ \rightleftharpoons \mathrm{H}^+ & + & \underline{\mathrm{TeO}_2} \\ & & & + \\ & & & \mathrm{H_2O} \\ & & & \uparrow \\ \mathrm{TeO_3^{2-} + H_2O} \rightleftharpoons \mathrm{OH}^- + & \mathrm{HTeO_3^-} \\ & & \uparrow \\ \mathrm{Cd}^{2+} & & \frac{1}{2}\mathrm{Cd}^{2+} & \mathrm{H}^+ \\ & & \uparrow \\ \mathrm{Cd}^{2+} & & \uparrow \\ \mathrm{CdTeO_3} & & \frac{1}{2}\mathrm{Cd}(\mathrm{OH})_2 \end{array}$$
(1)

The precipitation behavior of zinc tellurite in acid solution parallels that of cadmium tellurite. The only previous work on the precipitation of these compounds seems to be that of LENHER AND WOLESENKY⁶, who reported that CdTeO₃·₃H₂O is precipitated from cadmium chloride solution.

Mercuric tellurite

A near neutral solution of mercuric nitrate could not be prepared owing to

hydrolysis and precipitation of basic salts. Instead, a solution in dilute nitric acid was used. When this solution was mixed with a tellurite solution, a white suspension formed, later settling out as a white precipitate. This precipitate was soluble in dilute acids, being appreciably soluble at pH 1.2.

On titrating 25 ml of 0.02 M Hg(NO₃)₂, 0.01 M in nitric acid, with 0.05 M K₂TeO₃, both pH and conductometric end points gave a value of 12.5 ml of tellurite required for neutralization and precipitation (Fig. 1).

Neutralization of the nitric acid was found in a separate experiment to require 2.5 ml of the tellurite solution; hence, the precipitate was almost certainly a mixture of HgTeO₃ and TeO₂. Moreover, the amount of coprecipitated TeO₂ was found to increase with the acid concentration of the mercuric nitrate solution.

The presence of excess TeO₂ was confirmed by chemical analysis of the precipitate, which yielded the ratio 1.23 Te: I Hg for the precipitate from 0.02 M Hg(NO₃)₂/ 0.01 M HNO₃. Analysis of the filtrate showed that at pH 5.5 (titration end point—Fig. I) the mercuric concentration was 9.17×10^{-4} g-ion/liter, and the tellurite concentration was 9.70×10^{-4} g-ion/liter. No reference to mercuric tellurite was found in the literature.

Mercurous tellurite

To prevent precipitation of basic compounds, it was necessary to acidify the initial mercurous nitrate solution, which was standardized by oxidation with concentrated nitric acid, and determine the Hg^{2+} ion with EDTA. Mercuric ion was not detected in the original acidified solution.

On adding 0.05 M K₂TeO₃ to the mercurous solution, a stable, yellow precipitate was formed. By contrast, on adding mercurous nitrate solution to the tellurite solution, the yellow precipitate which first appeared turned grayish on stirring. However, the final precipitate in the presence of excess Hg₂²⁺ was light yellow in color. It is thus evident that in acid solution, tellurite is not reduced to tellurium by mercurous ion. The precipitates were soluble in dilute acids, being appreciably so at a pH of 1.25.

Precipitation tests showed that between 7 and 8 ml of $0.05 M \text{ K}_2 \text{TeO}_3$ was needed to precipitate the mercury from 25 ml $0.02 M \text{ Hg}_2(\text{NO}_3)_2/0.01 M \text{ HNO}_3$. The pH titration end point was 7.6 ml, so that allowing for the 2.5 ml of tellurite solution found to be needed to neutralize the nitric acid, the mercury was probably precipitated as Hg_2TeO_3. It was found that the amount of coprecipitated TeO_2 varied with the initial acid concentration of the mercurous solution.

Analysis of the filtrate at the titration end point, pH 5.5 (Fig. 1), showed that the concentrations of mercurous ion and tellurite in solution in contact with the mixed precipitate were 1.22×10^{-5} and 1.45×10^{-3} g-ion/liter, respectively.

2. The selenites of zinc, cadmium and mercury

Zinc and cadmium selenites

These compounds were formed as white, somewhat gelatinous precipitates, which were appreciably soluble below pH 3. The zinc salt was also soluble above pH 11.5. pH-titration curves showed indistinct end points in the region 1 M^{2+1} : SeO₃²⁻; the absence of sharp end points is associated with significant solubility of the precipitates. Filtrate compositions (Table I) indicated coprecipitation of metal hydroxide.

| Precipitate | Chukhlantsev ^{8,9} | | This work | | |
|----------------------------------|-----------------------------|-------------------------|-----------|-----------------------|-------------------------------|
| | pН | Cation g-10n/liter | ϕH | Cation g-ion/liter | Total selenite g-ion/liter |
| ZnSeO3 | 6.5 | 2.93×10 ⁻³ | 6.8 | 1.94×10^{-3} | 3.08 × 10-3 |
| CdSeO3 | 4.86 | 1.87×10^{-3} | 6.0 | 2.35×10^{-5} | 1.70×10^{-3} |
| Hg ₂ SeO ₃ | 3.05 | 2.6×10^{-5} | 3.4 | $4.97 	imes 10^{-5}$ | 7×10^{-3} |
| 2 | 2.22 | $\rm 1.1 	imes 10^{-4}$ | 2.2 | $4.57 	imes 10^{-4}$ | $< 1.3 \times 10^{-5}$ |

TABLE 1

SOLUBILITIES OF ZINC, CADMIUM AND MERCUROUS SELENITES

When a solution 0.02 M in cadmium nitrate and 0.01 M in nitric acid was titrated with 0.05 M potassium selenite solution, a volume of selenite solution in excess of that sufficient to form CdTeO₃ and to neutralize the acid was required to reach the end point. This suggests that an acid salt was formed. The acidic compound 3CdSeO₃·H₂SeO₃ has been prepared by MARKOVSKII⁷ from acid solutions of selenite and cadmium.

Mercurous selenite

Mercurous selenite was formed as a white, granular precipitate which was soluble in concentrated acids (about 4 N in the case of nitric acid). The precipitate was found by precipitation tests to have a composition near Hg₂SeO₃. pH titration showed, allowing for the volume of selenite to neutralize the acid, that the precipitate was Hg₂SeO₃ slightly enriched in SeO₂. The results of filtrate analysis for two experiments (namely, precipitation with excess selenite and with equivalent amounts of both components) are given in Table I.

CHUKHLANTSEV reported the following solubility products, $[M^{2+}][SeO_3^{2-}]$, for zinc⁸, cadmium⁸ and mercurous⁹ selenites: 2.58×10^{-7} , 1.29×10^{-9} and $3.8 \pm 2.2 \times 10^{-19}$, respectively. These values were obtained by mixing solutions in stoichiometric proportions and equilibrating the precipitates (stated to be near stoichiometric) with sulfuric or nitric acid solutions of known pH. The cation concentration in solution was measured, and this was assumed to be equal to the total selenite concentration. Our results are compared with those of CHUKHLANTSEV in Table I.

Mercuric selenite

Mercuric selenite was precipitated as a white, somewhat granular solid, soluble in 3-4 N acid and, as found by DIVERS¹⁰, soluble in a large excess of alkali selenite. Precipitation tests indicated the precipitation of HgSeO₃, in agreement with pH titration results (when the volume of selenite required for neutralization of the nitric acid was taken into account). According to SANKARANARAYANAN¹¹, selenite can be determined as HgSeO₃ if excess Hg²⁺ is present.

Analysis of the filtrate obtained on mixing $0.02 M \text{ Hg}(\text{NO}_3)_2/0.01 M \text{ HNO}_3$ and $0.05 M \text{ K}_2\text{SeO}_3$ gave a precipitate composition of HgSeO₃ in contact with a solution containing $7.83 \times 10^{-4} \text{ g-ion/liter}$ of Hg²⁺ and $1.20 \times 10^{-5} \text{ g-ion/liter}$ of total selenite at pH 2.2.

3. The selenates of zinc, cadmium and mercury

Zinc and cadmium selenates

These compounds are very soluble in aqueous solution and resemble the

corresponding sulfates. They are sufficiently well known to be included in handbook listings.

Mercuric selenate

Mercuric selenate was formed as a dark-orange precipitate when sodium selenate solution was added to an acidified mercuric nitrate solution. In contrast, when mercuric nitrate solution was added to selenate solution, the initial color of the precipitate was yellow, but turned orange on standing, finally becoming granular. The precipitate was appreciably soluble at pH 1.4.

pH titration showed an increase in acidity of the 0.02 M HgNO₃/0.01 M HNO₃ solution on first addition of selenate. This suggests that a basic salt was formed. Equation (2) shows a possible reaction.

$$2Hg^{2+} + SeO_4^{2-} + 2OH^- \rightarrow HgSeO_4 \cdot HgO + H_2O$$
⁽²⁾

This conclusion is in agreement with the work of AURIVILLIUS¹², who reports the formation of HgSeO₄, HgSeO₄·HgO and HgSeO₄·2HgO.

Precipitation tests confirmed that the precipitates were rich in mercury. However, it was found that the ratio of mercury to selenium was not constant, but depended upon the conditions of mixing. Analysis of a filtrate having a pH of 2 showed that the mercuric selenate is appreciably soluble at this pH and that a basic salt containing an atomic ratio of 2.68 Hg:1 Se was formed. The concentration of mercuric ion in contact with this precipitate was 2.28×10^{-3} and that of selenate was 8.7×10^{-3} g-ion/liter.

In the formation of a basic salt, the behavior of the selenate follows that of the sulfate. It is possible that the neutral salt could be prepared by repeated evaporation of mercury with selenic acid.

Mercurous selenate

Mercurous selenate was formed as a yellow-white precipitate from acidified mercurous nitrate and sodium selenate solutions. The precipitate was somewhat granular and became more so in acid solution, becoming soluble in 5-6 N nitric acid. It did not turn black under the action of light as claimed by CAMERON AND DAVY¹³.

pH titration showed only a very slight increase in acidity when sodium selenate was first added to the mercurous solution. It was concluded that the precipitate contained only a small proportion of basic mercurous selenate. Mercurous selenate thus parallels the sulfate, which is slowly hydrolyzed to give basic salts¹⁴.

Analysis of a filtrate having a pH of 2 showed that a basic salt containing 2.38 atoms of Hg for one of Se was formed; this composition corresponds approximately to the formula $5 \text{ Hg}_2\text{SeO}_4 \cdot \text{Hg}_2\text{O}$. The concentration of mercurous ion in the solution in contact with this precipitate was 8.33×10^{-4} g-ion/liter and that of selenate was 1.13×10^{-3} g-ion/liter.

4. The tellurates of zinc, cadmium and mercury

The tellurate compounds purchased (from British Drug Houses, Ltd.) were the ammonium salt, and the acid, $H_2TeO_4 \cdot 2H_2O$ (or H_6TeO_6). The ammonium salt was not easily water soluble, hence a sodium tellurate solution was prepared from the acid and sodium hydroxide. Owing to the weakness of telluric acid, the sodium tellurate solution was distinctly alkaline.

GROUP IIB CATIONS WITH OXYANIONS OF SELENIUM AND TELLURIUM

Zinc and cadmium tellurates

These compounds were not precipitated when telluric acid was added to zinc or cadmium solution. However, above pH 4 they were obtained as white, somewhat gelatinous precipitates during titration with sodium tellurate solution. No visible precipitation occurred in the early stages of titration and no sharp end points were observed (Fig. 2), thus indicating significant solubilities for both compounds.



Fig. 2. pH titration curves for tellurates.

Analysis of filtrates obtained after mixing solutions to the stoichiometric composition Zn(or Cd)TeO₄, confirmed that the tellurates are significantly soluble at pH 6. The precipitates contained two metal ions for each tellurate ion, corresponding to the orthotellurates Zn₂H₂TeO₆ and Cd₂H₂TeO₆. Concentrations of ions in contact with these precipitates were: for zinc tellurate, $[Zn^{2+}]=7.51 \times 10^{-3}$ and $[TeO_{4^2-}]=9.97 \times 10^{-3}$; for cadmium tellurate, $[Cd^{2+}]=3.68 \times 10^{-3}$ and $[TeO_{4^{2-}}]=7.97 \times 10^{-3}$.

The pH titration results suggest a precipitate composition nearer to $CdTeO_4$ than to $Cd_2H_2TeO_6$, and correspondingly for zinc tellurate. However, the end point had probably been displaced by the formation of hydrogen ion, as in eqn. (3):

$$2Zn^{2+} + TeO_4^{2-} + 2H_2O \rightarrow Zn_2H_2TeO_6 + 2H^+$$
(3)

The compound Zn_3TeO_6 has been prepared by JANDER AND KIENBAUM¹⁵ by digesting the initial precipitate from zinc and tellurate solution with excess zinc solution on a steam bath. They obtained $Zn_2H_2TeO_6$ as an intermediate.

The only reference found to cadmium tellurate was that of OPPENHEIM¹⁶, who reported a white precipitate easily soluble in acid.

Mercuric tellurate

Mercuric tellurate was formed as a finely-dispersed, yellow precipitate which coagulated on standing. The precipitate was appreciably soluble at pH 1.0–1.2.

pH titration of 25 ml of $0.0196 M Hg(NO_3)_2$ in $0.01 M HNO_3$ showed that a total of 12.3 ml of $0.047 M Na_2 TeO_4$ solution was needed to precipitate the mercury and to neutralize the acid. During the early stages of titration, the solution became more acid (Fig. 2), and subsequently the pH did not rise until about 5 ml of tellurate solution had been added. The variation of pH during titration is probably related to the formation of orthotellurate as in the example of eqn. (3). Because of the immediate precipitation of mercuric tellurate, a net generation of hydrogen ions is observed initially. This effect is more pronounced than with the more soluble zinc and cadmium tellurates.

If calculations are made for the total volume of tellurate solution needed to precipitate the mercury and to neutralize the original nitric acid as well as the liberated acid, a difference of only 0.2 ml of tellurate solution is involved between the formation of $Hg_2H_2TeO_6$ and Hg_3TeO_6 . Thus, the composition of the precipitate could not be determined from the titration volume. However, analysis of the filtrate obtained after precipitation at pH 1.6 gave a precipitate composition of $Hg_2H_2TeO_6$. The concentrations of mercuric ion and total tellurate in contact with this precipitate were 2.82×10^{-3} and 8.30×10^{-4} g-ion/liter, respectively.

No reference was found to $Hg_2H_2TeO_6$, although JANDER AND KIENBAUM¹⁵ prepared Hg_3TeO_6 and CHRISTIE¹⁷ determined its structure. CHRISTIE prepared his material using the method of HUTCHINS¹⁸, who equilibrated a mercuric tellurate precipitate with excess mercuric ion at 80°C for several weeks. HUTCHINS found that

TABLE II

| Compound | Composition | Form of ppt. | Color |
|-----------------------------------|--|---|------------------|
| Zinc and cadmium tellurites | $MTeO_3 + TeO_2$, acid soln; $MTeO_3 + M(OH)_2$, near neutral solution | Somewhat gelatinous | White |
| Mercury (II) tellurite | Variable mixture of $HgTeO_3 + TeO_2$ from acid solutions | Finely dispersed | White |
| Mercury (I) tellurite | Variable mixture of $Hg_2TeO_3 + TeO_2$ from acid solutions | Finely dispersed | White |
| Zinc and cadmium selenites | $MSeO_3$, neutral solution; excess SeO_2 , acid solution | Somewhat gelatinous | White |
| Mercury (II) selenite | Normal salt, $HgSeO_3$ | Granular | White |
| Mercury (I) selenite | Hg_2SeO_3 +slight excess of SeO ₂ | Granular | White |
| Zinc and cadmium tellurates | Orthotellurates, $M_2H_2TeO_6$ | Somewhat gelatinous | White |
| Mercury (II) tellurate | ${\rm Orthotellurate,}\ Hg_2H_2TeO_6$ | Finely dispersed; coagulates quickly | Yellow |
| Mercury (I) tellurate | Normal salt, Hg_2TeO_4 | Finely dispersed | Yellow |
| Mercury (II) selenate | Basic salt | Finely dispersed; coagulates quickly | Orange |
| Mercury (I) selenate | Basic salt | Granular | Yellow- white |

PROPERTIES OF THE PRECIPITATES

mercuric tellurate precipitates, including the normal tellurate HgTeO₄, are converted to orthotellurate in the presence of water.

Mercurous tellurate

Mercurous tellurate was formed as a yellow precipitate from mercurous and tellurate solutions. The precipitate tended to be colloidal, but coagulated on standing. It was appreciably soluble at pH values below 0.8. Analysis of the filtrate obtained after precipitation at pH 2 showed that the precipitate had a composition close to Hg_2TeO_4 , with solution concentrations of mercurous ion and tellurate equal to 3.48×10^{-3} and 7.25×10^{-4} .

No increase in acidity was observed during the early stages of titration between 0.02 M Hg₂(NO₃)₂ in 0.01 M HNO₃ and 0.05 M Na₂TeO₄ (Fig. 2), as would be the case if insoluble orthotellurates were formed. Taking into account the amount of tellurate to neutralize the nitric acid, the results indicate a precipitate composition of Hg₂TeO₄.

HUTCHINS¹⁸ reported that the precipitate composition could vary from HgHTeO₄ to Hg₂TeO₄·HgO, but that all precipitates were converted to HgHTeO₄ on long standing.

TABLE III

SOLUBILITY DATA

| Compound | Solubility at room temp. (g liter) | pH at which solubility measured | pH of appreciable solubility |
|------------------------|---|---------------------------------------|------------------------------------|
| Zinc tellurite | 0.023 (as ZnTeO ₃) ^a | 7.5 | 1.5 |
| Cadmium tellurite | 0.020 (as CdTeO3) a | 7.5 | 1.5 |
| Mercury (II) tellurite | 0.345 (as HgTeO ₃) ° | 5.5 | 1.2 |
| Mercury (I) tellurite | 0.070 (as Hg ₂ TeO ₃) ° | 5.5 | 1.25 |
| Zinc selenite | 0.593 (as ZnSeO ₃) ^a | 6.8 | 3 |
| Cadmium selenite | 0.405 (as CdSeO ₃) ^a | 6 | 3 |
| Mercury (II) selenite | 0.0039 (as HgSeO3) ° | 2.2 | 3-4 N acid |
| Mercury (I) selenite | 0.241 (as Hg ₂ SeO ₃) ^c | 2.2 | $\frac{1}{4}$ N acid |
| Zinc tellurate | 1.33 (as Zn ₂ H ₂ TeO ₆) ^c | 6 | 4 |
| Cadmium tellurate | 0.72 (as $Cd_2H_2TeO_6)^{\circ}$ | 6 | 4 |
| Mercury (II) tellurate | 0.26 (as Hg ₂ H ₂ TeO ₆) ^c | 1.6 | I |
| Mercury (I) tellurate | 0.22 (as Hg_2TeO_4) ° | 2 | 0.8 |
| Mercury (I) selenate | 0.16 (as $Hg_{2^{2+}}$) | 2 | 5-6 N acid |
| Mercury (II) selenate | 0.46 (as Hg^{2+}) | 2 | I.4 |
| Zinc selenate | ZnSeO ₄ 5H ₂ O soluble* | | |
| Cadmium selenate | $CdSeO_4 \cdot 2H_2O v. sol.*$ | | |

*Based on anion concentration.

^eBased on cation concentration

*Handbook of Chemistry and Physics, 45th edition, Chemical Rubber Co.

TABULATION OF DATA

Composition, color and form of the precipitates are given in Table II. Solubilities of the precipitates at known pH, and the pH values below which the compounds are appreciably soluble, are given in Table III.

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