Chapter 18 – The Analysis of A Solution for Mg (II) Ions

NAME:

Lab Section:

Date:  

Sign-Off:
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Introduction

Mg -- Magnesium

Mg is obtained from underground brines and seawater as the chloride salt. It is a silvery-white metal. It is malleable and ductile at high temperatures. It was used in flash powders. It is still used in military flares and incendiary bombs -- it burns hot and bright. Since Al is hard at machining temperatures, Mg is alloyed with it to make Magnalium (1-15% Mg, 0-1.75% Cu and Al) or Dowmetal (8.5% Al, 0.15% Mn, 2% Cu, 1% Cd, 0.5% Zn and 87.85% Mg) which is easier to machine.

Experimental

Obtain a known sample of Group V cations and procure your super that you previously stored covered.

To both samples, add a few gtts 0.5M ammonium sulfate and 0.25M ammonium oxalate. Boil in a boiling water bath and centrifuge. Discard any ppt that may have formed. To the super, add concentrated ammonia a drop at a time until the solution is alkaline to litmus, then add 2-4 drops of 0.5M disodium hydrogen phosphate. Place some Parafilm ® on top of the tube and shake vigorously. Place in a test tube rack and let it stand for 5-10 minutes. A white crystalline ppt that is soluble in 6M HOAc is positive for Mg(II).

Flow chart and problem set follow, below.
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Problem Set -- Examination Level Problems in Qualitative Analysis

<table>
<thead>
<tr>
<th>Chemical</th>
<th>(K_{sp})</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\text{Al(OH)}_3)</td>
<td>(1.4\times10^{-34})</td>
</tr>
<tr>
<td>(\text{Cu(OH)}_2)</td>
<td>(2.2\times10^{-20})</td>
</tr>
<tr>
<td>(\text{AgSCN})</td>
<td>(1.0\times10^{-12})</td>
</tr>
<tr>
<td>(\text{SnS})</td>
<td>(8\times10^{-28})</td>
</tr>
<tr>
<td>(\text{ZnS})</td>
<td>(2\times10^{-26})</td>
</tr>
<tr>
<td>(\text{CaSO}_4)</td>
<td>(2\times10^{-4})</td>
</tr>
<tr>
<td>(\text{AgI})</td>
<td>(1.5\times10^{-16})</td>
</tr>
<tr>
<td>(\text{AgCl})</td>
<td>(1.8\times10^{-10})</td>
</tr>
</tbody>
</table>

Table of Standard Reduction Potentials

<table>
<thead>
<tr>
<th>Half-reaction</th>
<th>Potential (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\text{Co}^{2+} + 2e^- \rightarrow \text{Co})</td>
<td>-0.28</td>
</tr>
<tr>
<td>(\text{Mg}^{2+} + 2e^- \rightarrow \text{Mg})</td>
<td>-2.36</td>
</tr>
<tr>
<td>(\text{Au}^{3+} + 3e^- \rightarrow \text{Au})</td>
<td>+1.40</td>
</tr>
<tr>
<td>(\text{Ag}^+ + e^- \rightarrow \text{Ag})</td>
<td>+0.80</td>
</tr>
<tr>
<td>(\text{Fe}^{3+} + e^- \rightarrow \text{Fe}^{2+})</td>
<td>+0.77</td>
</tr>
<tr>
<td>(\text{Cu}^{2+} + e^- \rightarrow \text{Cu}^{+})</td>
<td>+0.15</td>
</tr>
<tr>
<td>(\text{Ni}^{2+} + 2e^- \rightarrow \text{Ni})</td>
<td>-0.23</td>
</tr>
<tr>
<td>(\text{Al}^{3+} + 3e^- \rightarrow \text{Al})</td>
<td>-1.66</td>
</tr>
</tbody>
</table>
1. Which of the following ions does not belong with the others?
   A. Cu$^{2+}$
   B. As$^{3+}$
   C. Ag$^{+}$
   D. Sn$^{2+}$

2. Which of the following ions does NOT give a strongly alkaline reaction?
   A. S$^{2-}$
   B. HSO$_4^-$
   C. SO$_3^{2-}$
   D. PO$_4^{3-}$

3. Which anion would give a vile odor when treated with 6M H$_2$SO$_4$ and would turn lead acetate paper black?
   A. NO$_2^-$
   B. SO$_3^{2-}$
   C. CO$_3^{2-}$
   D. S$^{2-}$

4. Given the following reaction:
   \[ H_2SO_3 + Cu(OH)_2(s) \rightarrow Cu^{2+} + SO_3^{2-} + 2H_2O \]
   which of the following expressions best expresses the $K_{eq}$?
   A. \( (K_aK_w^2)/K_{sp} \)
   B. \( (K_wK_{sp}^2)/K_a \)
   C. \( (K_w^2K_{sp})/K_a^2 \)
   D. \( (K_{sp}K_a)/K_w^2 \)

5. Given the dissociation of aluminum hydroxide (MW = 78): \( Al(OH)_3(s) \rightarrow Al^{3+} + 3 OH^- \)
   determine the solubility of the aluminum hydroxide under the following conditions: 0.05M OH$^-$. 
   A. 8.74X10$^{-29}$ g/L
   B. 7.28X10$^{-32}$ g/L
   C. 3.024X10$^{-29}$ g/L
   D. 1.75X10$^{-38}$ g/L
6. If the dissociation of H₂S in water is as follows:

\[ \text{H}_2\text{S} + \text{H}_2\text{O} \rightarrow 2\text{H}_3\text{O}^+ + \text{S}^{2-} \]

and

\[ K_d = \frac{[\text{H}_3\text{O}^+]^2[S^{2-}]}{[\text{H}_2\text{S}]} = 6.8 \times 10^{-23} \]

and [H₂S] in water is 0.1M, what is the pH necessary to precipitate Zn²⁺ but not Sn²⁺ as sulfides? (10⁻⁵ rule) The solution is 0.1M in each cation.

A. 0.0837  
B. 0.0353  
C. -0.416  
D. -0.465

7. A quick method to determine if a "silver" pebble is galena (PbS) or someone's filling (Ag-Hg amalgam) would be to treat it with:

A. H₂SO₄  
B. HCl  
C. KOH  
D. HNO₃

8. What color would you expect lead acetate paper to turn in the previous question?

A. Red  
B. Purple  
C. Yellow  
D. Black

9. Will silver thiocyanate form if 26 mL 0.03M silver nitrate are mixed with 74 mL 0.045M potassium thiocyanate?

A. Yes  
B. No

10. Which ion does not belong with the others?

A. Ca²⁺  
B. Sr²⁺  
C. Fe³⁺  
D. Ba²⁺
11. If a solution is 0.005M in Al\(^{3+}\) and Cu\(^{2+}\) ions, what percent of Al\(^{3+}\) remains unprecipitated before Cu(OH)\(_2\) precipitates following the addition of KOH to the solution?

A. 0.000303
B. 4.45X10\(^{-22}\)
C. 2.49X10\(^{-25}\)
D. 0.50

12. How many drops (NOT parts of drops) of 12M H\(_2\)SO\(_4\) are required to dissolve 20 mg MgCO\(_3\) (MW = 84.3)?

A. 2
B. 1
C. 4
D. 3

13. If an ammoniacal solution is 0.5M in NH\(_3\) and 0.06M in NH\(_4^+\), and the K\(_i\) = 1.8X10\(^{-5}\), what is the hydroxide ion concentration in the solution?

A. 1.5X10\(^{-4}\)M
B. 2.16X10\(^{-6}\)M
C. 0.06M
D. 5.4X10\(^{-7}\)M

14. Would the hydroxide ion in the previous question be enough to precipitate Cu\(^{2+}\) as Cu(OH)\(_2\) if the concentration of Cu\(^{2+}\) is 0.0003M?

A. Yes
B. No

15. If you were to make a battery using Au and Au\(^{3+}\) with Al and Al\(^{3+}\) as the half cells, which metal would you need to place as the cathode?

A. Au
B. Al
C. Neither

16. What is the E\(_{\text{cell}}^o\) of the previous question?

A. -3.06V
B. 0.26V
C. 0.40V
D. 3.06V
17. Given the following battery (E\text{cell} = 0.121V):

\[ \text{Ni|Ni(OH)}_{2}(\text{sat'd}), \text{Ni}^{2+}|\text{Ni}^{2+} (0.1M)|\text{Ni} \]

Calculate the K\text{sp} for Ni(OH)\text{2}.

A. 3.27X10^{-5}
B. 5.45X10^{-16}
C. 2.18X10^{-15}
D. 1.4X10^{-13}

18. Given the following salts and their K\text{sp}'s:

<table>
<thead>
<tr>
<th>Salt</th>
<th>K\text{sp}</th>
</tr>
</thead>
<tbody>
<tr>
<td>CuS</td>
<td>8X10^{-36}</td>
</tr>
<tr>
<td>AgCl</td>
<td>1.8X10^{-10}</td>
</tr>
<tr>
<td>SrCO\text{3}</td>
<td>7X10^{-10}</td>
</tr>
<tr>
<td>ZnS</td>
<td>8X10^{-25}</td>
</tr>
</tbody>
</table>

Which compound is most soluble in water?

A. SrCO\text{3} 
B. AgCl 
C. ZnS 
D. CuS 

19. Which compound from number 18 is the least soluble in water?

A. SrCO\text{3} 
B. AgCl 
C. ZnS 
D. CuS 

20. Plaster is made up of CaSO\text{4} and is still periodically used to construct casts to immobilize fractures as they heal. One weakness of plaster casts is that one must wrap them in plastic when showering -- otherwise the cast will "dissolve". If the density of the plaster is 0.97 g/cm\text{3} and one showers with water flowing at a rate of 600 L/hour and the cast is 2 cm thick, how long will it take the water to make a hole 5 cm in diameter through the cast?

A. 0.97 hours 
B. 0.033 hours 
C. 1.98 minutes 
D. A and C 
E. B and C
21. Which of the following ions gives a carmine flame test?
   A. Na⁺
   B. Sr²⁺
   C. Ba²⁺
   D. Ca²⁺

22. Which of the following ions gives a strong, persistent yellow flame test?
   A. Na⁺
   B. Sr²⁺
   C. Ba²⁺
   D. Ca²⁺

23. Which of the following anions would give a blue coloration or precipitate which would indicate the presence of a strong reducing anion?
   A. CO₃²⁻
   B. NO₃⁻
   C. SO₄²⁻
   D. S²⁻

MATCHING

Match the anion with the release of the gas from the action of 6M H₂SO₄ upon the solid sample.

24. NO₂⁻  A. Colorless, odorless gas
25. CO₃²⁻  B. Colorless gas with vile odor
26. S²⁻    C. Red-brown gas with sharp odor
27. SO₃²⁻  D. Colorless gas with sharp odor

28. Which of the following ions WILL form a precipitate in the presence of S²⁻ and HCl?
   A. Al³⁺
   B. Sb⁵⁺
   C. Co²⁺
   D. Ni²⁺

29. Which of the following ions reacts qualitatively with dimethylglyoxime (DMG)?
   A. Ni²⁺
   B. Co²⁺
   C. Fe³⁺
   D. Mn²⁺
   E. A and B
   F. B and C
30. Our bodies depend greatly on calcium levels being carefully regulated in our blood, skeletal muscles and heart, to name a few tissues. The $K_{sp}$ for $\text{Ca}_3(\text{PO}_4)_2$ at 25°C is $2.07 \times 10^{-33}$. If we assume that only the total average $\text{Ca}^{2+}$ concentration in the blood ($2.35 \times 10^{-3} \text{ M}$) contributes to the solubility of $\text{Ca}_3(\text{PO}_4)_2$ and that only the free average phosphorus concentration (0.94 mmol/L; in the forms of phosphate, hydrogen phosphate and dihydrogen phosphate) likewise contributes to the solubility of $\text{Ca}_3(\text{PO}_4)_2$, what does the ion product say about the $\text{Ca}^{2+}$ and $\text{PO}_4^{3-}$ concentrations in our blood at 37°C versus the $K_{sp}$ at 25°C?

A. Blood is unsaturated with the two ions  
B. Blood is saturated with the two ions  
C. Blood is supersaturated with the two ions  
D. None of the above

31. If the equilibrium constant for:

$$\text{Al} + 3\text{Cu}^{2+} \rightarrow \text{Al}^{3+} = 3\text{Cu}^+$$

is $7.13 \times 10^{91}$ and $R = 0.00831 \text{ kJ/mol/K}$ at 25°C, calculate the Gibb’s free energy change for this reaction.

A. -524 kcal/mol  
B. -524 kJ/mol  
C. 524 kJ/mol  
D. 524 kcal/mol

32. Will the reaction in number 31 proceed as written?

A. Yes  
B. No

33. An unknown sample in a test tube had 6M NaOH added to it, was mixed, then a piece of red litmus placed in the neck of the test tube and was covered. Within two minutes, the litmus paper did not change color. What cation was not present?

A. $\text{NH}_4^+$  
B. $\text{Mg}^{2+}$  
C. $\text{Na}^+$  
D. $\text{K}^+$
34. Given the following battery:

\[ \text{Co|Co}^{2+} (0.025\text{M})||\text{Mg}^{2+} (0.005\text{M})|\text{Mg} \]

Calculate the \( E_{\text{cell}} \)

A. -2.101V  
B. -0.277V  
C. +2.114V  
D. +2.37V

35. Will the reaction in the previous question "go" as written?

A. Yes  
B. No

36. Given the following battery:

\[ \text{Pt|Fe}^{2+} (0.1\text{M}), \text{Fe}^{3+}||\text{Ag}^+ (0.5\text{M})|\text{Ag} \]

Calculate the \([\text{Fe}^{3+}]\) if the \( E_{\text{cell}} = 0.0112\text{V} \).

A. 0.01M  
B. 0.1M  
C. 10M  
D. 1M

37. \( \text{Cu(NH}_3\text{)}_4^{2+} \)
   A. Yellow to orange precipitate

38. \( \text{Ni(OH)}_2 \)
   B. White precipitate

39. \( \text{CdS} \)
   C. Green precipitate

40. \( \text{AgCl} \)
   D. Deep blue solution

41. \( \text{Bi}^\text{III} \)
   E. Jet black solution

42. Cations in the silver, lead and mercury group are precipitated as halides (specifically as chlorides). Which halides of these cations are the most soluble?

A. Iodides  
B. Bromides  
C. Chlorides  
D. Fluorides
43. A solution contains 0.04M NaI and 0.008M NaCl. AgNO₃ is gradually poured into this solution. Which precipitates first?

A. AgCl
B. AgI
C. Both precipitate at the same time
D. All of the above

MATCHING

Match the reaction with the product.

44. Ag⁺ + Cl⁻  
A. SrCO₃

45. Pb²⁺ + SO₄²⁻  
B. AgCl

46. Hg₂²⁺ + 2Cl⁻  
C. Bi(OH)₃

47. Sr²⁺ + CO₃²⁻  
D. Cu(OH)₂

48. Cu²⁺ + 2OH⁻  
E. PbSO₄

49. Mn²⁺ + ClO₃⁻  
F. MnO₂

50. Bi³⁺ + 3OH⁻  
G. Hg₂Cl₂

References/Sources/Bibliography