

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

NAME:

Lab Section:

Date:

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

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.

<p>0I Obtain a known sample of Group V cations and procure your super that you previously stored covered (“2S 5”).</p>		
		
<p>1T To both samples, add a few gtts 0.5M ammonium sulfate and 0.25M ammonium oxalate. Boil in a boiling water bath and centrifuge.</p>		
 		
<p>2P Discard any ppt that may have formed.</p>	<p>2S 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.</p>	
		
<p>3P A white crystalline ppt that is soluble in 6M HOAc is positive for Mg(II).</p>		

Problem Set -- Examination Level Problems in Qualitative Analysis

Table of K_{sp} 's		
	Chemical	K_{sp}
Al(OH) ₃	Aluminum hydroxide	1.4×10^{-34}
Cu(OH) ₂	Copper (II) hydroxide	2.2×10^{-20}
AgSCN	Silver thiocyanate	1.0×10^{-12}
SnS	Tin (II) sulfide	1.0×10^{-28}
ZnS	Zinc sulfide	8×10^{-25}
CaSO ₄	Calcium sulfate	2×10^{-4}
AgI	Silver iodide	1.5×10^{-16}
AgCl	Silver chloride	1.8×10^{-10}

Table of Standard Reduction Potentials

Half-reaction	Potential (V)
$\text{Co}^{2+} + 2\text{e}^- \rightarrow \text{Co}$	-0.28
$\text{Mg}^{2+} + 2\text{e}^- \rightarrow \text{Mg}$	-2.36
$\text{Au}^{3+} + 3\text{e}^- \rightarrow \text{Au}$	+1.40
$\text{Ag}^+ + \text{e}^- \rightarrow \text{Ag}$	+0.80
$\text{Fe}^{3+} + \text{e}^- \rightarrow \text{Fe}^{2+}$	+0.77
$\text{Cu}^{2+} + \text{e}^- \rightarrow \text{Cu}^+$	+0.15
$\text{Ni}^{2+} + 2\text{e}^- \rightarrow \text{Ni}$	-0.23
$\text{Al}^{3+} + 3\text{e}^- \rightarrow \text{Al}$	-1.66

1. Which of the following ions does not belong with the others?

- A. Cu^{2+}
- B. As^{3+}
- C. Ag^+
- D. Sn^{2+}

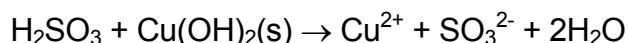
2. Which of the following ions does NOT give a strongly alkaline reaction?

- 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_2SO_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:



which of the following expressions best expresses the K_{eq} ?

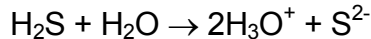
- A. $(K_a K_w^2)/K_{\text{sp}}$
- B. $(K_w K_{\text{sp}}^2)/K_a$
- C. $(K_w^2 K_{\text{sp}})/K_a^2$
- D. $(K_{\text{sp}} K_a)/K_w^2$

5. Given the dissociation of aluminum hydroxide (MW = 78): $\text{Al}(\text{OH})_3(\text{s}) \rightarrow \text{Al}^{3+} + 3 \text{OH}^-$

determine the solubility of the aluminum hydroxide under the following conditions: 0.05M OH^- .

- A. $8.74 \times 10^{-29} \text{ g/L}$
- B. $7.28 \times 10^{-32} \text{ g/L}$
- C. $3.024 \times 10^{-29} \text{ g/L}$
- D. $1.75 \times 10^{-38} \text{ g/L}$

6. If the dissociation of H₂S in water is as follows:



and

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

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 $\text{Cu}(\text{OH})_2$ precipitates following the addition of KOH to the solution?

- A. 0.000303
- B. 4.45×10^{-22}
- C. 2.49×10^{-25}
- D. 0.50

12. How many drops (NOT parts of drops) of 12M H_2SO_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 $K_i = 1.8 \times 10^{-5}$, what is the hydroxide ion concentration in the solution?

- A. $1.5 \times 10^{-4}\text{M}$
- B. $2.16 \times 10^{-6}\text{M}$
- C. 0.06M
- D. $5.4 \times 10^{-7}\text{M}$

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

- A. Yes
- B. No

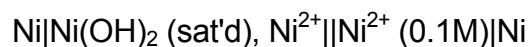
15. If you were to make a battery using Au and Au^{3+} with Al and Al^{3+} as the half cells, which metal would you need to place as the cathode?

- A. Au
- B. Al
- C. Neither

16. What is the E_{cell}° of the previous question?

- A. -3.06V
- B. 0.26V
- C. 0.40V
- D. 3.06V

17. Given the following battery ($E_{\text{cell}} = 0.121\text{V}$):



Calculate the K_{sp} for $\text{Ni}(\text{OH})_2$.

- A. 3.27×10^{-5}
- B. 5.45×10^{-16}
- C. 2.18×10^{-15}
- D. 1.4×10^{-13}

18. Given the following salts and their K_{sp} 's:

Salt	K_{sp}
CuS	8×10^{-36}
AgCl	1.8×10^{-10}
SrCO ₃	7×10^{-10}
ZnS	8×10^{-25}

Which compound is most soluble in water?

- A. SrCO₃
- B. AgCl
- C. ZnS
- D. CuS

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

- A. SrCO₃
- B. AgCl
- C. ZnS
- D. CuS

20. Plaster is made up of CaSO_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^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. Sr^{2+}
- C. Ba^{2+}
- D. Ca^{2+}

22. Which of the following ions gives a strong, persistent yellow flame test?

- A. Na^+
- B. Sr^{2+}
- C. Ba^{2+}
- D. Ca^{2+}

23. Which of the following anions would give a blue coloration or precipitate which would indicate the presence of a strong reducing anion?

- A. CO_3^{2-}
- B. NO_3^-
- C. SO_4^{2-}
- D. S^{2-}

MATCHING

Match the anion with the release of the gas from the action of 6M H_2SO_4 upon the solid sample.

- | | |
|------------------------|----------------------------------|
| 24. NO_2^- | A. Colorless, odorless gas |
| 25. CO_3^{2-} | B. Colorless gas with vile odor |
| 26. S^{2-} | C. Red-brown gas with sharp odor |
| 27. SO_3^{2-} | D. Colorless gas with sharp odor |

28. Which of the following ions WILL form a precipitate in the presence of S^{2-} and HCl?

- A. Al^{3+}
- B. Sb^{5+}
- C. Co^{2+}
- D. Ni^{2+}

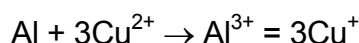
29. Which of the following ions reacts qualitatively with dimethylglyoxime (DMG)?

- A. Ni^{2+}
- B. Co^{2+}
- C. Fe^{3+}
- D. Mn^{2+}
- 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 $Ca_3(PO_4)_2$ at $25^\circ C$ is 2.07×10^{-33} . If we assume that only the total average Ca^{2+} concentration in the blood ($2.35 \times 10^{-3} M$) contributes to the solubility of $Ca_3(PO_4)_2$ 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 $Ca_3(PO_4)_2$, what does the ion product say about the Ca^{2+} and PO_4^{3-} concentrations in our blood at $37^\circ C$ versus the K_{sp} at $25^\circ C$?

- 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:



is 7.13×10^{91} and $R = 0.00831 \text{ kJ/mol/K}$ at $25^\circ C$, 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

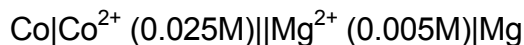
32. Will the reaction in number 31 proceed as written?

- A. Yes
- B. No

33. An unknown sample in a test tube had $6M \text{ NaOH}$ 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. NH_4^+
- B. Mg^{2+}
- C. Na^+
- D. K^+

34. Given the following battery:



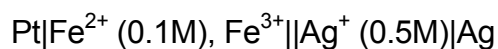
Calculate the E_{cell}

- 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:



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

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

MATCHING

Match the compound with the color.

- | | |
|-------------------------------------|---------------------------------|
| 37. $\text{Cu}(\text{NH}_3)_4^{2+}$ | A. Yellow to orange precipitate |
| 38. $\text{Ni}(\text{OH})_2$ | B. White precipitate |
| 39. CdS | C. Green precipitate |
| 40. AgCl | D. Deep blue solution |
| 41. Bi° | 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. AgNO_3 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. $\text{Ag}^+ + \text{Cl}^-$ | A. SrCO_3 |
| 45. $\text{Pb}^{2+} + \text{SO}_4^{2-}$ | B. AgCl |
| 46. $\text{Hg}_2^{2+} + 2\text{Cl}^-$ | C. $\text{Bi}(\text{OH})_3$ |
| 47. $\text{Sr}^{2+} + \text{CO}_3^{2-}$ | D. $\text{Cu}(\text{OH})_2$ |
| 48. $\text{Cu}^{2+} + 2\text{OH}^-$ | E. PbSO_4 |
| 49. $\text{Mn}^{2+} + \text{ClO}_3^-$ | F. MnO_2 |
| 50. $\text{Bi}^{3+} + 3\text{OH}^-$ | G. Hg_2Cl_2 |

References/Sources/Bibliography

Baskerville, C. and Curtman, L.J.: **A Course in Qualitative Chemical Analysis.** (The Macmillan Company: New York) © 1915.