Precipitation and Water Purity

Professor Thomas Hamade, UM-SJTU JI

&

Department of Chemistry, SJTU

(longest experiment: 3:20 lab work only 1 hr)

SAFETY, DISPOSAL & COURSE EVALUATION

8TH WEEK PRESENTATIONS

CHECK CANVAS FOR SCHEDULE & LOCATION

Groups must be present for the entire period of 3HOURS of their SECTION session

VC211 Presentation Instructions

Group Presentation is scheduled on the 8th week. And here are some general instructions for you to follow.

1. **You must attend 10 minutes before the start of the presentation. Points will be deducted for lateness.**
2. **All group members must sit together in their assigned place. You cannot walk around during the presentation.**
3. **You must be quiet when other groups are doing their presentation. If you are found talking with each other, points will be deducted.**
4. **Groups must be present for the entire period of their section sessions. You must show respect for other students' work.**
5. **Every group has 8 minutes to do their presentation. If you go beyond your time, your presentation will be stopped by your TAs.**

SAFETY HIGHLIGHTS

☐YOU ARE RESPONSIBLE FOR YOUR OWN SAFETY FIRST THEN OTHERS

☐BROKEN GLASS, PREVENTION& DISPOSAL ☐HOW TO WASH & RINSE GLASSWARE ☐WEAR GOGGLES & LAB COATS

☐KEEPGLASSWARE AT LEAST 20cm AWAY FROM EDGE OF BENCH

☐CLUTTER (MESS)

☐CHEMICAL WASTE & DISPOSAL (ORGANIC, INORGANIC &, CORROSIVES, & SOLIDS) ☐WASTING CHEMICALS BE CONSERVATIVE & PROTECT ENVIRONMENT☐IMMEDIATELY STORE AWAY STOCK CHEMICALS (COVER ON TIGHTENED & TOP BENCH)

☐SAFETY RUBBER GOLVES (CORROSIVE LIQUIDS RESISTANT & SOLVENTS RESISTANCE)

☐SAFETY CLOTH GLOVES & TONGUES: HEAT PROTECTION, HOT PLATES, & BURN PROTECTION ☐FIR HAZARDS & PROTECTION (EXTINGUISHERS) ☐SPATULAS ☐CHEMICAL TRANSPORTATION PROHIBITED, NOT EVEN ALLOWED TO TAKE OUTSIDE THE DOOR

SUMMARY OF E5 ALR REPORT (include cover page)

I. AFTER-LAB REPORT (ALR) INSTRUCTIONS FOR EXPERIMENT E5
II. OBJECTIVES
III. INTRODUCTION & BACKGROUND
IV. PRE-LAB ASSIGNMENT
V. GENERAL INSTRUCTIONS
VI. EXPERIMENTAL PROCEDURES (ignore all faded text sections that are identified as "skip this part")

PART 1. *What is a Precipitate?*
a. Information
b. Procedure

PART 2.A. Is Precipitation Predicable

a. Information
b. Notes to the Procedure
c. Procedure
d. Data Analysis
e. Optional Points to Consider (skip this part)

PART 2.B. *Can I Identify it?* (skip this part)

PART 3. *Concentration and Precipitation*

a. Information
b. Notes to the Procedure
c. Procedure
d. Additional Information
e. E. Data Analysis: Use Table 3, Table 4 & Table 5 to record your results
f. Extensions (skip this part)
g. Optional Points to Consider (skip this part)

PART 4. *Solvent Pollution & Precipitation*

a. Information
b. Notes to the Procedure
c. Procedure
d. Data Analysis
e. Optional Points to Consider (skip this part)

PART 5. Can I purify it? (skip this part)

VII. REPORTS OF RESULTS
Pre-Laboratory Report
Team Report: Parts 1-5
Team Assessment Form: Instructor may have different evaluation form
Grading (skip this page)

REFERENCES

NEXT WEEK E5 EXPERIMENT REMINDER

I. AFTER-LAB REPORT (ALR) INSTRUCTIONS FOR EXPERIMENT E5

This is a group experiment but each student must submit the entire individual report by the end of the experiment E5, however data analysis and discussions can be shared among the group members. You must adhere to all safety rules.

So prepare all the following report sections entirely ahead of time. At end of experiment you must collect all below sections and give to instructor before leaving the lab.

1. Type cover page (format same as instructed before).
2. Study ahead of lab (using references, internet and library resources) section IV. PRE-LAB ASSIGNMENTS as instructed and follow section V. GENERAL INSTRUCTIONS.
3. Copy or type from this document and from references a brief description (no more than 1 page total) of (sections II, II & references at end of this document): objectives, introduction, background, and theory. To help you with this, you may use your own typed summary of the quoted references and the additional references at the end of the report (do not include the additional references in your report). Again no more than one page for this section.
4. Ahead of time, read & follow instructions of experimental procedures in sections VI.
5. Copy/paste/type the procedures given in section VI (your choice to copy as is, no need to handwrite). Leave some spaces as needed to handwrite your data and notes.
6. There are no PLE or PLQ for this experiment, however, you must copy/paste/type (as is the entire section VII. REPORTS OF RESULTS) to include the following portions that appear before the additional references at the end of this document. **Leave enough space to handwrite yours/team answers during and immediately after the experiment is completed: (ignore all faded text sections that are identified as "skip this part")**
    a. Pre-Laboratory Report: Answer the questions ahead of lab.
    b. Team Report: All parts 1 through 5
    c. Team Assessment Form
    d. Laboratory Discussion Team / Presentation Grading Form
    e. Laboratory Discussion
    f. Grading (must include in report for instructor to complete or you get no grade)

HOW TO SUBMIT E5 ALR REPORT?

1. **Teams to meet in assigned areas under the supervision of the TA. You are not allowed to leave until E5 is completed, glassware and lab areas clean to original or better condition, discuss entire data and report with the TA and then submit your completed individual reports.**
2. **Each student must submit individual report**
3. **Omit all sections that said in procedure "Omit" such as Part 5, or when data is not available such as CRC Handbook , data bank base on compute (not available). But you must clearly mark across that entire section the word "OMIT".**
4. **The group report part is to be completed by the group and submitted to the group leader report. While the remaining members of the group will write across that page of their own team report "SEE TEAM LEADER REPORT & give his name xxxx". This way you save time in duplicating the Team Report data.**

TABLE 4.1 • Solubility Guidelines for Common Ionic Compounds in Water

Soluble Ionic Compounds		Important Exceptions (below not soluble)
Compounds containing	NO_3^-	None
	CH_3COO^-	None
	Cl^-	Compounds of Ag^+, Hg_2^{2+}, and Pb^{2+}
	Br^-	Compounds of Ag^+, Hg_2^{2+}, and Pb^{2+}
	I^-	Compounds of Ag^+, Hg_2^{2+}, and Pb^{2+}
	SO_4^{2-}	Compounds of Sr^{2+}, Ba^{2+}, Hg_2^{2+}, and Pb^{2+}
Insoluble Ionic Compounds		**Important Exceptions (below soluble)**
Compounds containing	S^{2-}	Compounds of NH_4^+, the alkali metal cations, Ca^{2+}, Sr^{2+}, and Ba^{2+}
	CO_3^{2-}	Compounds of NH_4^+ and the alkali metal cations
	PO_4^{3-}	Compounds of NH_4^+ and the alkali metal cations
	OH^-	Compounds of NH_4^+, the alkali metal cations, Ca^{2+}, Sr^{2+}, and Ba^{2+}

Goals for Experiment

- **Part 1:** precipitation rxn & filtration
- **Part 2:** Designated cations groups I & II precipitation trends with designated anions
- **Part 3:** Effect of cations & anions concentration on precipitation. Q_{sp} trends relative to K_{sp}
- **Part 4:** Solubility of salts with polar & non-polar solvents: I. $CaCl_2$ & II. $K_2C_2O_4$ solubilities in H_2O, Acetone, & Hexane.
- **Part 5:** Omit.
- Prepare discussion presentation.
- Complete team report during lab work.

VC211 EXPERIMENT E5 DATASHEET: PRECIPITATION & WATER PURITY

STDNT: ID: SECTION#: _____ TA: _____

GRP#:

PART 1: What is a precipitate. Each 2 studests tests 1 sample once

	$CuSO_4$ 5mL (0.1M) Color	$BaCl_2$ 5mL (0.1M) Color	$CuSO_4$ + $BaCl_2$ Color	ppt↓ Yes/No	Filtrate observed property
2students					
2students					

PART 2.A. *Is Precipitation Predictable? Group efforts, test only Group I or Group II as assigned, 2 raw reactions/student. Clear = means no precipitate, then record solution color.*

CATION GROUP I	CATION GROUP II	REF WATER	Cl^- 2drops	CrO_4^{2-} 2drops	I^- 2drops	$C_2O_4^{2-}$ 2drops	S^{2-} 2drops	SO_4^{2-} 2drops	SPECTATOR IONS	
Cations no. drops→		2drops	2drops	2drops	2drops	2drops	2drops	2drops	GROUP I	GROUP II
Na^+	K^+	clear / colorless								
Ba^{2+}	Mn^{2+}	clear / colorless								
Mg^{2+}	Ca^{2+}	clear / colorless								
Co^{2+}	Sr^{2+}	clear / colorless								
Ni^{2+}	Cr^{3+}	clear / colorless								
Cu^{2+}	Fe^{3+}	clear / colorless								
Al^{3+}	Zn^{2+}	clear / colorless								
Pb^{2+}	Ag^+	clear / colorless	White ppt↓	Brown ppt↓	Yellow ppt↓	White ppt↓	Black ppt↓	White ppt↓		

PART 3. *Conce. & Precip.: Each team usesTable 3 & design different reactions than Table,minimum 2 reactions per student*

TABLE 5: RECORD YOUR RAW DATA HERE similar to Table 4. Add only 2 drops of each reactant

REACTION #	REACTANT #1 & CONC	REACTANT #2 & CONC	OBSERVATIONS

TABLE 3: DESIGN REACTIONS FROM HERE

REACTION #	REACTANT #1	REACTANT #2
I	$Pb(NO_3)_2$	KI
II	$Pb(NO_3)_2$	NaOH
III	$AgNO_3$	KI
IV	$ZnSO_4$	NaOH
V	$CaCl_2$	$K_2C_2O_4$
VI	$CaCl_2$	NaOH

TABLE 4: SAMPLE REACTIONS DESIGN

Reactant #	REACTANT #1& Conc.	REACTANT #2 & Conc.	OBSERV.
II-1	0.10M $Pb(NO_3)_2$	0.10M NaOH	
II-2	0.10M $Pb(NO_3)_2$	1.0M NaOH	
II-3	0.01M $Pb(NO_3)_2$	0.01M NaOH	
IV-1	0.10M $ZnSO_4$	0.10M NaOH	
IV-2	0.10M $ZnSO_4$	1.0M NaOH	
IV-3	0.01M $ZnSO_4$	0.01M NaOH	
V-1	0.10M $CaCl_2$	0.10M $K_2C_2O_4$	
V-2	0.01M $CaCl_2$	0.01M $K_2C_2O_4$	

PART 4. *Solvent Pollution & Preci.:Group efforts, each 2 students study solubility of 1 solid*

TABLE 6: *Solids Solubility in Polar & Non-Polar Solvents (total 6 samples to test)*

Solid Type (thoroughly dry inside test tubes)	Ionized Water 2mL	Acetone 2mL	Hexane 2mL
I. $CaCl_2$ <0.2g			
II. $K_2C_2O_4$ <0.2g			
Supernatant (I + II)			

Note: Use the solubility table from CH 4, VC210 to predict if precipatate is formed from mixing the supernatants

E5 GENERAL INSTRUCTIONS

This is a group experiment where each student shares data with his members of the group & groups share data with each other as instructed below for each part of the experiment. At the end of the experiment you must turn in individual reports immediately before leaving the laboratory or you will get -0- points for this experiment.

1.At start of lab after my lecture, TA will walk around the groups, collect E4 reports, examine the pre-lab report for E5 and make each group give brief few minutes discussion of last week experiment.

2.Immediately as soon as you finish your experiment, each group will gather one after the other in front of the TA and discuss your results and conclusions of today's experiment.

3.After that, you must start cleaning your entire work bench areas, including disposing waste in proper containers and wash glassware with soap & water using brush.

4.Then after that the instructor will inspect your cleaned area and if he satisfied he will tell you to proceed discussing the results with your teams and prepare the final team report so you can give that to the TA before leaving the lab.

Precipitation

- **A solid comes out of solution:**

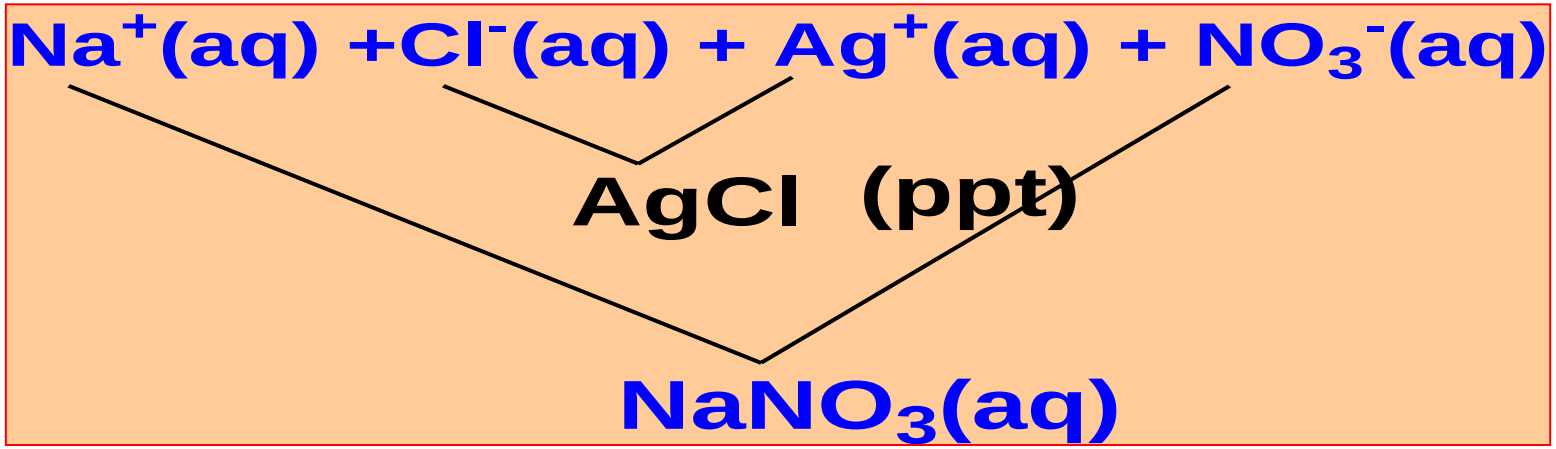
$NaCl\ (aq) + AgNO_3\ (aq) \rightarrow$ solid

clear and colorless $\rightarrow$ solid

Why when: $Na^+ + Ag^+ + Cl^- + NO_3^-$ generates AgCl ppt↓?

Answer: can be found in Table 4.1 slide

Precipitation reactions



1. **The positive ion of a dissolved salt combines with the negative ion from a different dissolved salt.**
2. **The recombined ions may stay in solution or come out of solution in the form of a solid called a "precipitate (*ppt*)".**

Part 1: *What is the Precipitate?*

Each 2 students in a group must do 1 sample once, so each group will test 2 samples (once each).

Use clean/dry graduated cylinder and pour into small beaker, but wash and dry cylinder when switching between different solutions, filter into another small beaker

$$CuSO_4\,(aq) + BaCl_2(aq) \rightarrow BaSO_4\,(s) + CuCl_2(aq)$$

5mL 0.1M + 5mL 0.1M

available as Cu^{2+} & Ba^{2+} in small bottle s with eyedropper covers

ppt↓

Why $BaSO_4$ ppt↓?
See Table 4.1 slide

Compare: ppt↓ if $Q > K_{sp}$, aqueous if $Q < K_{sp}$

Gravity Filtration

Determining Whether Precipitation Occurs

$BaSO_4\ (s) \leftrightarrow Ba^{2+}\ (aq) + SO_4^{2-}\ (aq)$

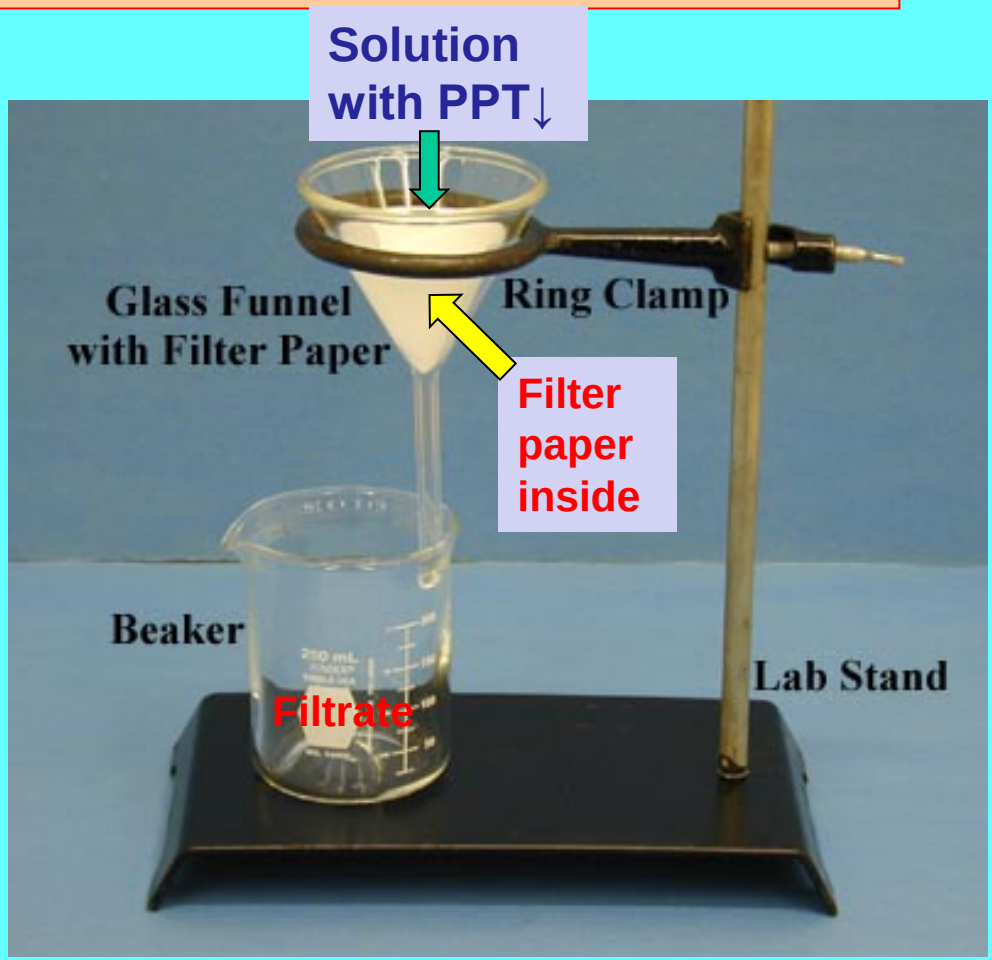
$$Q_{ip} = c_{Ba^{2+}} c^2_{SO4^{2-}}$$ **$>K_{sp}$ ppt↓**

$$Q_{ip} = c_{Ba^{2+}} c^2_{SO4^{2-}}$$ **$<K_{sp}$ no ppt**

$$Q_{ip} = c_{Ba^{2+}} c^2_{SO4^{2-}}$$ **$= K_{sp}$ @ saturation**

Gravity Filtration

- The correct way to set up for a gravity filtration is shown here in the photo.
- Note that the tip of the funnel is touching the side of the beaker to reduce splashing.
- Filtrate: Solution filtered from precipitate



After folding filter to funnel shape, crimp the outer edge slightly for better sealing when wet.

Part 2. Precipitation Studies.

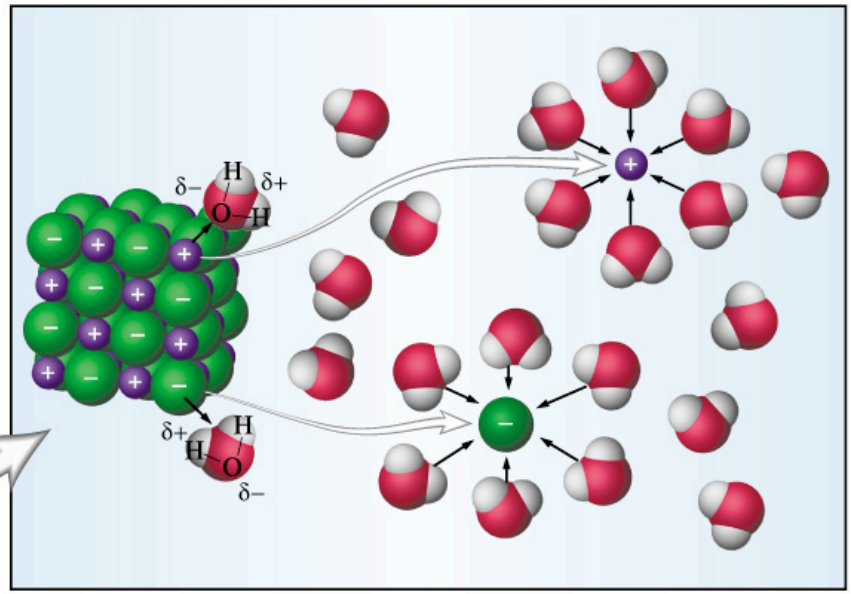
A. Is Precipitation Predictable?

B. Can I Identify It? OMIT

- **Is the solubility of a metal ion predictable from the position of its element in the Periodic Table?**
- **Is there a difference in the solubility of salts containing singly versus multiply charged ions?**
- **Discussion questions**

Background: Water and Salt Solubility

"In solution the ions are mixed with water molecules and free to move about in solution".

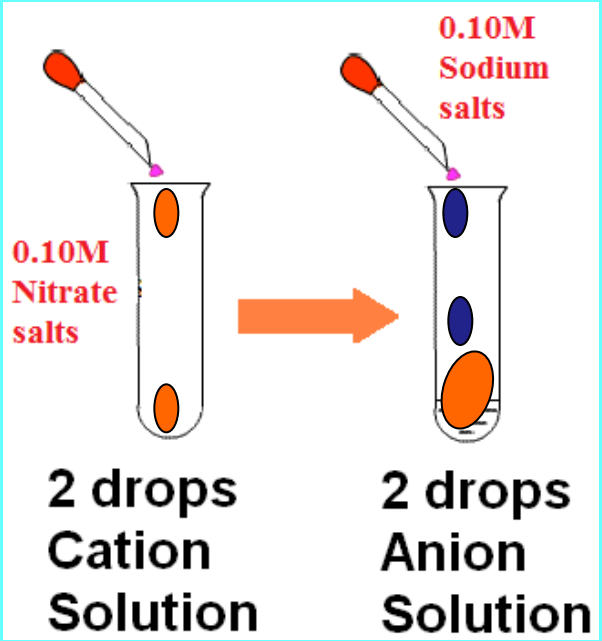


"In the solid, the salt ions are fixed in a rigid lattice."

" Water molecules reduce the effective charges of the ions and thus the salt dissociates."

Cation groups (0.10M Nitrates soluble salts): Each team randomly assigned (I) or (II)

I	Na^{+}	Ba^{2+}	Mg^{2+}	Co^{2+}	Ni^{2+}	Cu^{2+}	Al^{3+}	Pb^{2+}
II	K^{+}	Mn^{2+}	Ca^{2+}	Sr^{2+}	Cr^{2+}	Fe^{3+}	Zn^{2+}	Ag^{+}

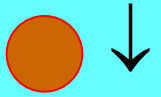
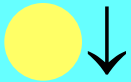
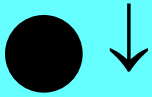


Record observations

One group tests cations (I) while the other group tests cations (II). Each student in a group tests two of the group selected cations. The two groups shares results.

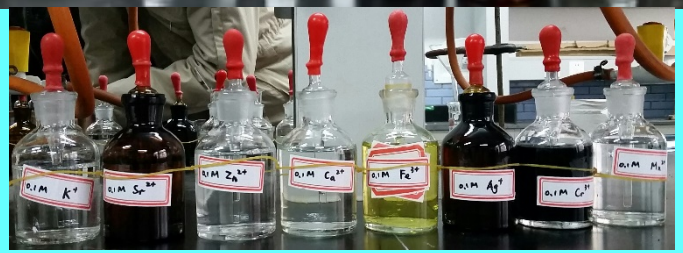
Soluble salts **Sodium/Potassium Salts**

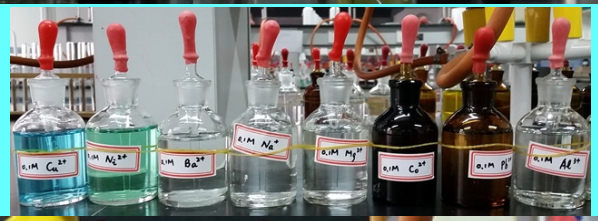
Anion Groups (0.10M)

Cations	REF	Cl^-	CrO_4^{2-}	I^-	$C_2O_4^{2-}$	S^{2-}	SO_4^{2-}
Ag^+	clear	○↓			○↓		○↓

Part 2A. Table: Compare your results with the other group I/II

Alert: Shown cations and anions reagents may be not arranged as tabulated in E5 lab manual





Cation groups of nitrate salts

Anions of sodium or potassium salts

Tabl1: CATION GROUPS TO PRECIPITATE (0.10 M nitrate salts for each cation), p52 manual.

GROUP I	Na^+	Ba^{2+}	Mg^{2+}	Co^{2+}	Ni^{2+}	Cu^{2+}	Al^{3+}	Pb^{2+}
GROUP II	K^+	Mn^{2+}	Ca^{2+}	Sr^{2+}	Cr^{3+}	Fe^{3+}	Zn^{2+}	Ag^+

Table 2: ANION GROUPS PRECIPITATING REAGENTS: (0.10 M sodium salts for each anion),

SELECT CATION GROUP I OR GROUP II BUT NOT BOTH, THEN ADD YOUR OBSERVATIONS ON THE TABLE ACCORDING TO INSTRUCTIONS & USING GROUP II EXAMPLE for Ag^+ (CAUTION: COLORS MAY NOT BE AS SHOWN). COMPARE YOUR RESULTS WITH THE OTHER GROUP I/II. Clear means no ppt.

CATION GROUP I 2drops	CATION GROUP II 2drops	REF 2drops	Cl^- 2drops	CrO_4^{2-} 2drops	I^- 2drops	$C_2O_4^{2-}$ 2drops	S^{2-} 2drops	SO_4^{2-} 2drops	SPCTR GROUP I	SPCTR GROUP II
Na^+	K^+	clear								
Ba^{2+}	Mn^{2+}	clear								
Mg^{2+}	Ca^{2+}	clear								
Co^{2+}	Sr^{2+}	clear								
Ni^{2+}	Cr^{3+}	clear								
Cu^{2+}	Fe^{3+}	clear								
Al^{3+}	Zn^{2+}	clear								
Pb^{2+}	Ag^+	clear	White ppt↓	Brown ppt↓	Yellow ppt↓	White ppt↓	Black ppt↓	White ppt↓		

Spectator Ions

A **spectator ion** is an ion that exists as a reactant and a product in a chemical equation during precipitation. It is observed in the reaction but do not affect equilibrium.

What are the Spectator ions in the aqueous reaction of silver nitrate (aq) with potassium chloride(aq)?

$AgNO_3(aq) + KCl(aq) \longrightarrow AgCl(s) + KNO_3(aq)$

$Ag^+(aq) + NO_3^-(aq) + K^+(aq) + Cl^-(aq)$

$\rightarrow$ $AgCl(s)$ (ppt↓) + $K^+(aq) + NO_3^-(aq)$

The K^+ and NO_3^- **ions** are **spectator ions** since they remain unchanged on both sides of the equation. Because they appear on both sides of the equation in the same form, they can be cancelled. Thus, the net ionic equation for the reaction is:

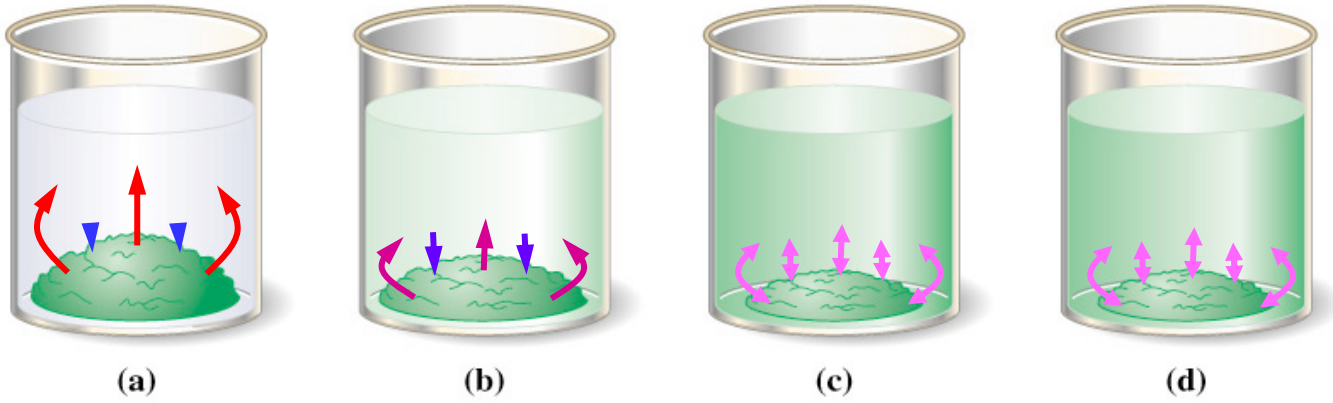
$Ag^+(aq) + Cl^-(aq) \rightarrow$ **$AgCl(s)$**

Compare: ppt↓ if $Q > K_{sp}$, aqueous if $Q < K_{sp}$

Part 3: Water Purity and Concentration

Compare: ppt↓ if $Q > K_{sp}$, aqueous if $Q < K_{sp}$

- **Precipitation occurs only when the solubility limit (of a salt) is exceeded.**
- **Saturated solution** = contains the maximum amount of solute that can be dissolved in a given solution volume at given temp.



Dynamic equilibrium: **rate of crystallization = rate of dissolving**

Precipitation reactions = Equilibrium Systems

Compare: ppt↓ if $Q > K_{sp}$, aqueous if $Q < K_{sp}$
equilibrium if $Q = K_{sp}$

- **When precipitation occurs, some reactant ions remain in solution:**
- **$Ag^+ + Cl^- \leftrightarrow AgCl\ (s)$**

"In reality, it is understood there is both a forward and reverse arrow!"

The Solubility Equilibrium Equation And K_{sp}

$CaF_2\ (s) \leftrightarrow\ Ca^{2+}\ (aq) + 2\ F^-\ (aq)$

$K_{sp} = [Ca^{2+}][F^-]^2$

$$Q_{ip} = c_{Ca^{2+}} c_{F^-}^2$$

Ion products or Quotient

Determining Whether Precipitation Occurs

$CaF_2\,(s) \leftrightarrow Ca^{2+}\,(aq) + 2\,F^-\,(aq)$

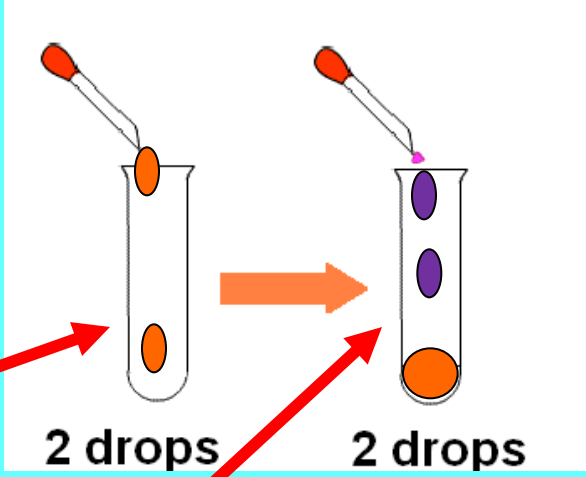
$Q_{ip} = c_{Ca^{2+}} c_{F^-}^2$ **$>K_{sp}$** **ppt↓**

$Q_{ip} = c_{Ca^{2+}} c_{F^-}^2$ **$<K_{sp}$** **no ppt**

$Q_{ip} = c_{Ca^{2+}} c_{F^-}^2$ **$=K_{sp}$** **sat.**

Table 3: Goal to observe ppt↓ at various concentrations.

Reagents available as cations and anions in small bottle s with eyedropper covers



Reaction #	Reactant #1	Reactant #2
I	$Pb(NO_3)_2$	KI
II	$Pb(NO_3)_2$	NaOH
III	$AgNO_3$	KI
IV	$ZnSO_4$	NaOH
V	$CaCl_2$	$K_2C_2O_4$
VI	$CaCl_2$	NaOH

GROUP WORK: 8 SAMPLES/GROUP (2 SAMPLES/STUDENT)

The TA will instruct you how to work together and approve the design of your own select reactions. A group will end up doing either 8 or 9 different reaction trials, depending on dilution limits, so each student will do at least 2 different reactions. Each group designs the reactants to differ by composition and by concentrations. Here groups should alternate reactions and compare results with each other. SEE EXAMPLE REACTIONS FOR A GROUP NEXT SLIDE.

Example: How to reduce concentrations?

Dilute 1 drop 0.1M NaOH with 9 drops H_2O to make about ½ mL 0.01M NaOH

Table 2: Example Reactions

Reaction #	Reactant #1	Reactant #2
II-1	0.10M $Pb(NO_3)_2$	0.10M NaOH
II-2	0.10M $Pb(NO_3)_2$	1.0M NaOH
II-3	0.01$Pb(NO_3)_2$	0.01M NaOH
IV-1	0.10M $ZnSO_4$	0.10M NaOH
IV-2	0.10M $ZnSO_4$	1.0M NaOH
IV-3	0.01M $ZnSO_4$	0.01M NaOH
V-1	0.10M $CaCl_2$	0.10M $K_2C_2O_4$
V-2	0.01M $CaCl_2$	0.01M $K_2C_2O_4$

TABLE 4: Example of reactions that may be selected by a particular group of your class, say Group # 5.

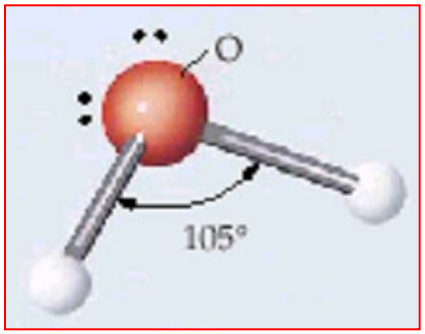
REACTION #	REACTANT #1	REACTANT #2	OBSERVATIONS
II-1	0.10M $Pb(NO_3)_2$	0.10M NaOH	
II-2	0.10M $Pb(NO_3)_2$	1.0M NaOH	
II-3	0.01M $Pb(NO_3)_2$	0.01M NaOH	
IV-1	0.10M $ZnSO_4$	0.10M NaOH	
IV-2	0.10M $ZnSO_4$	1.0M NaOH	
IV-3	0.01M $ZnSO_4$	0.01M NaOH	
V-1	0.10M $CaCl_2$	0.10M $K_2C_2O_4$	
V-2	0.01M $CaCl_2$	0.01M $K_2C_2O_4$	

TABLE 5: Another example of alternative reactions that may be selected by next group of your class.

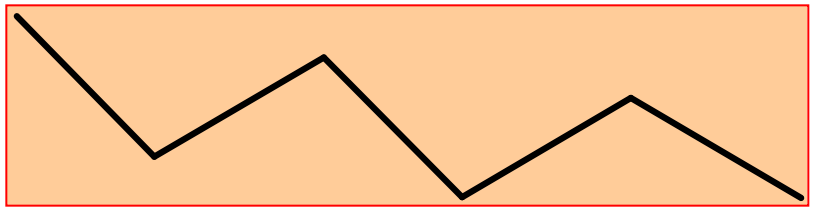
REACTION #	REACTANT #1	REACTANT #2	OBSERVATIONS
I-1	0.10M $Pb(NO_3)_2$	1.0M KI	
I-2	0.10M $Pb(NO_3)_2$	0.10M KI	
I-3	0.01M $Pb(NO_3)_2$	0.01M KI	
III-1	0.10M $AgNO_3$	1.0M KI	
III-2	0.10M $AgNO_3$	0.10M KI	
III-3	0.01M $AgNO_3$	0.01M KI	
VI-1	0.10M $CaCl_2$	0.10M NaOH	
VI-2	0.01M $CaCl_2$	0.01M NaOH	

Part 4: Solvent Pollution and Precipitation

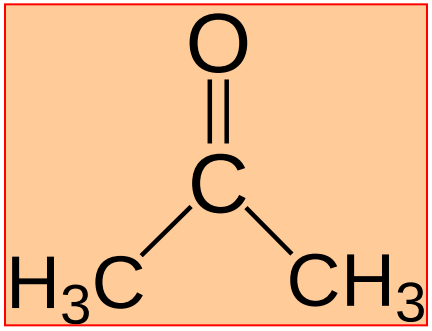
- **Water (H_2O) is very polar.**



- **Hexane (C_6H_{14}) is nonpolar.**

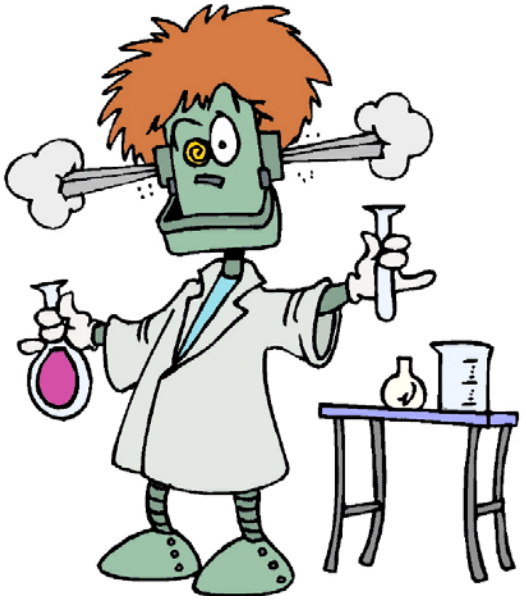


- **Acetone (CH_3COCH_3) is moderately polar.**



Salt solubility and polar molecules

- **Salts do NOT dissociate and thus do NOT dissolve in NONPOLAR solvents.**



GROUP WORK: FOR EACH REACTION (IN WATER OR IN ACETONE OR IN HEXANE) EACH GROUP TESTS SOLUBILITY OF BOTH SOLIDS I. CaCl2 & II. K2C2O4 (TOTAL 6 SAMPLES), THEN EACH 2 STUDENTS OF A GROUP TESTS EITHER THE FIRST OR THE SECOND SOLID SOLUBILITY (3SAMPLES EACH 2 STUDENTS).

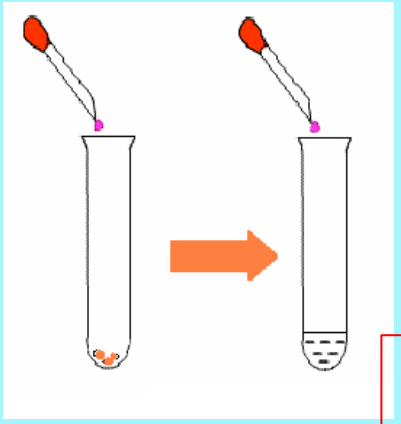
1. DO THE REACTION WITH WATER

$CaCl_2$	$K_2C_2O_4$

I. $CaCl_2(s)$

+2mL H_2O

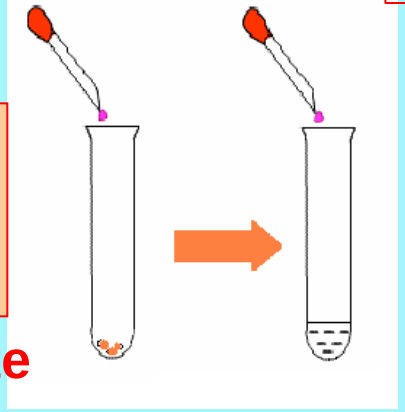
Calcium Chloride



II. $K_2C_2O_4(s)$

+2mL H_2O

Potassium Oxalate



Mix supernatant liquids in one test tube w/o the solids

ppt?

Do not use graduated cylinder, just use eye dropper. Each 20 drops of water are about 1 mL

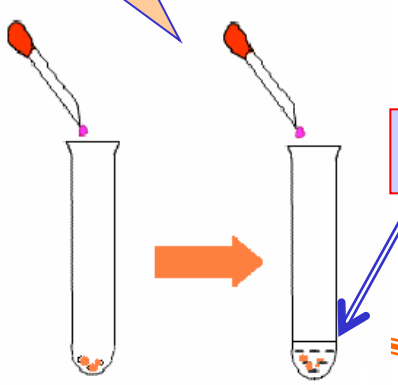
Dried test tubes!

2. DO REACTION AGAIN WITH ACETONE

$CaCl_2$	$K_2C_2O_4$

$CaCl_2$

+2mL acetone



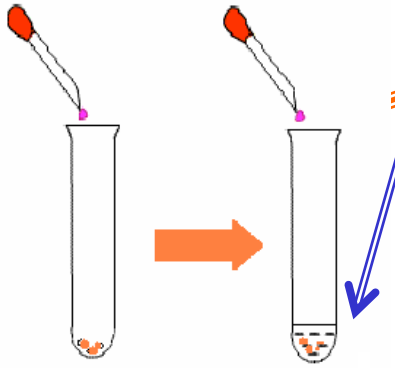
DECANT

Mix the supernatant liquids in one test tube

ppt?

$K_2C_2O_4$

+2mL acetone



Do not use graduated cylinder, just use eye dropper. Each 20 drops of liquid are about 1 mL

3. DO REACTION AGAIN WITH HEXANE

SUMMARY OF E5: PART 4
SOLUBILITY OF SOLIDS IN POLAR & NONE-POLAR SOLVENTS

TABLE 6: *Solids Solubility in Polar & Non-Polar Solvents (total 6 samples to test)*

Solid Type	Ionized Water	Acetone	Hexane
I.$CaCl_2$			
II.$K_2C_2O_4$			
Supernatant (I + II)			

Supernatant liquid is the liquid lying above a solid residue after crystallization, precipitation, centrifugation, or other process. Typically the liquid is decanted or pipetted out to separate from the precipitate solids

Team Report

In the lab

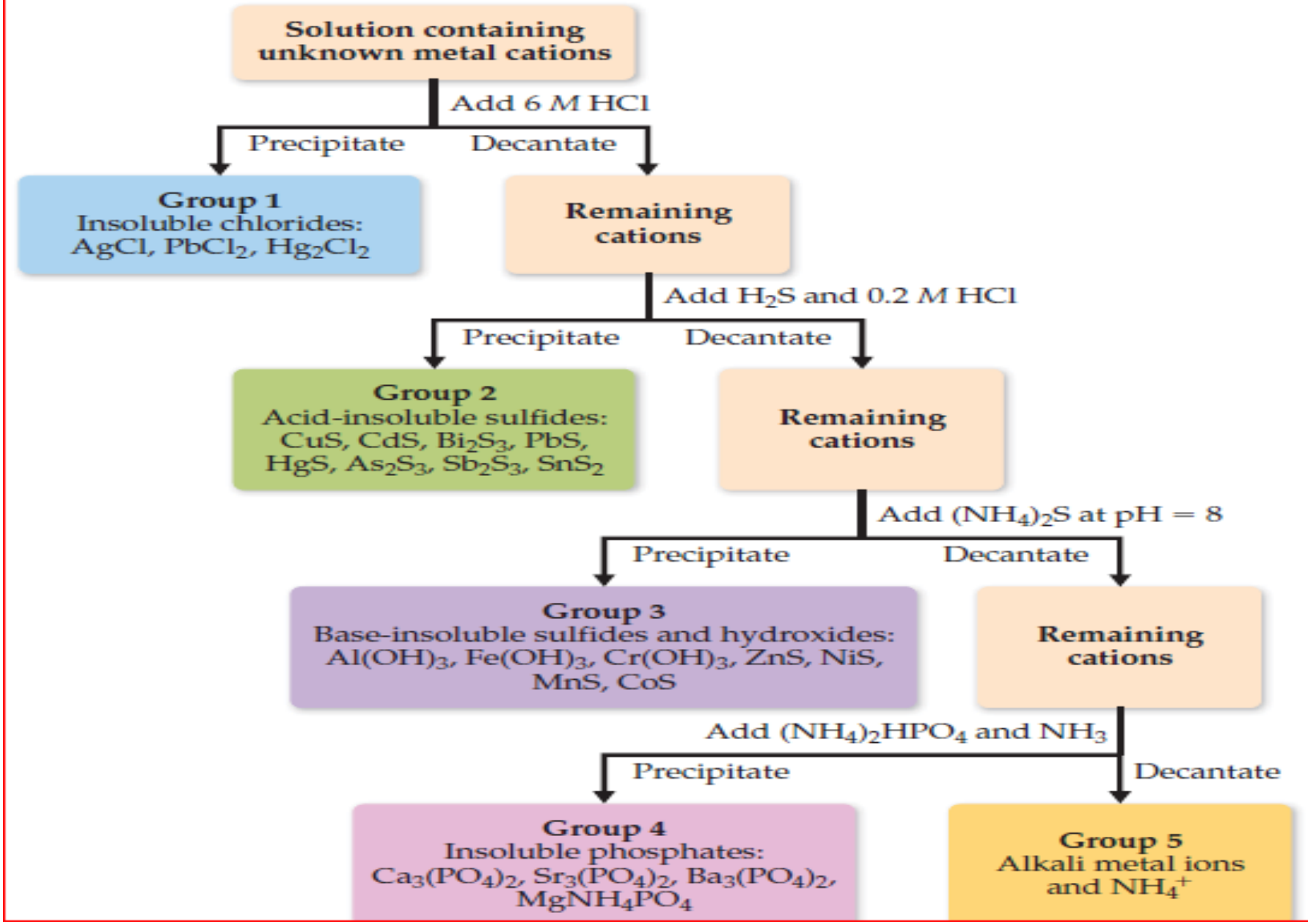
- **Finish the Team Report.**

Homework

- **After-lab Team Report.**
- **Prepare discussion presentation.**

REFERENCE: CH17 VC210 (P722-782) SOLUBILITY EQUILIBRIA & PRECIPITATION FROM *AQUEOUS* REACTIONS

If a solution contained a mixture of Cu^{2+} and Zn^{2+} ions, would this separation scheme work? After which step would the first precipitate be observed?



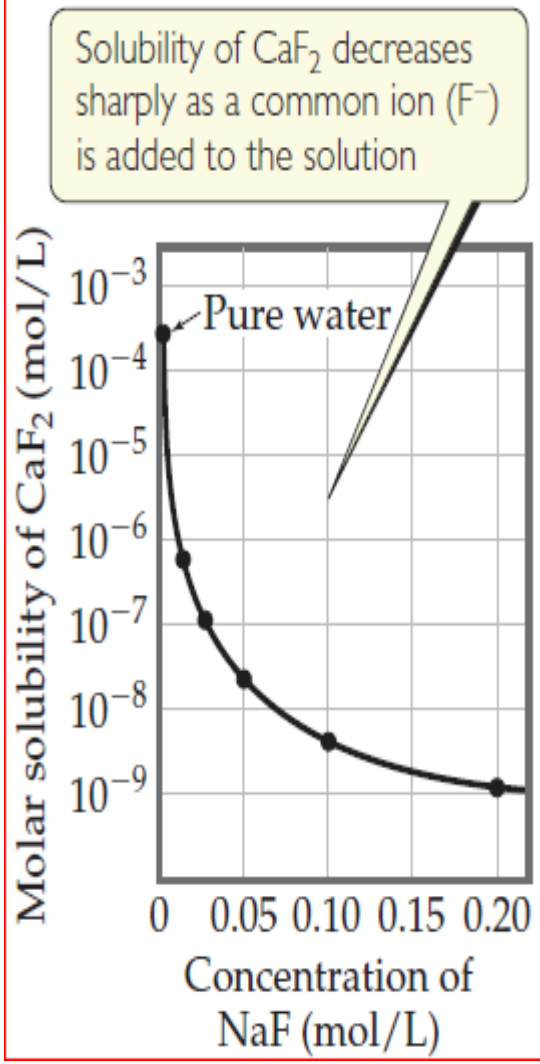
Group 1. *Insoluble chlorides:* Of the common metal ions, only Ag^+, Hg_2^{2+}, and Pb^{2+} form insoluble chlorides. When HCl is added to a mixture of cations, therefore, only AgCl, Hg_2Cl_2, and $PbCl_2$ precipitate, leaving the other cations in solution. The absence of a precipitate indicates that the starting solution contains no Ag^+, Hg_2^{2+}, or Pb^{2+}.

Group 2. *Acid-insoluble sulfides:* After any insoluble chlorides have been removed, the remaining solution, now acidic, is treated with H_2S. Only the most insoluble metal sulfides—CuS, Bi_2S_3, CdS, PbS, HgS, As_2S_3, Sb_2S_3, and SnS_2—precipitate. (Note the very small values of K_{sp} for some of these sulfides in Appendix D.) Those metal ions whose sulfides are somewhat more soluble—for example, ZnS or NiS—remain in solution.

Group 3. *Base-insoluble sulfides and hydroxides:* After the solution is filtered to remove any acid-insoluble sulfides, it is made slightly basic, and $(NH_4)_2S$ is added. In basic solutions the concentration of S^{2-} is higher than in acidic solutions. Thus, the ion products for many of the more soluble sulfides are made to exceed their K_{sp} values and precipitation occurs. The metal ions precipitated at this stage are Al^{3+}, Cr^{3+}, Fe^{3+}, Zn^{2+}, Ni^{2+}, Co^{2+}, and Mn^{2+} (The Al^{3+}, Fe^{3+}, and Cr^{3+} ions do not form insoluble sulfides; instead they precipitate as insoluble hydroxides, as Figure 17.23 shows.)

Group 4. *Insoluble phosphates:* At this point the solution contains only metal ions from groups 1A and 2A of the periodic table. Adding $(NH_4)_2HPO_4$ to a basic solution precipitates the group 2A elements Mg^{2+}, Ca^{2+}, Sr^{2+}, and Ba^{2+} because these metals form insoluble phosphates.

Group 5. *The alkali metal ions and NH_4^+:* The ions that remain after removing the insoluble phosphates are tested for individually. A flame test can be used to determine the presence of K^+, for example, because the flame turns a characteristic violet color if K^+ is present.



Common-Ion Effect

The presence of either $Ca^{2+}(aq)$ or $F^-(aq)$ in a solution reduces the solubility of CaF_2, shifting the solubility equilibrium to the left:

$$CaF_2(s) \rightleftharpoons Ca^{2+}(aq) + 2\,F^-(aq)$$

Addition of Ca^{2+} or F^- shifts equilibrium, reducing solubility

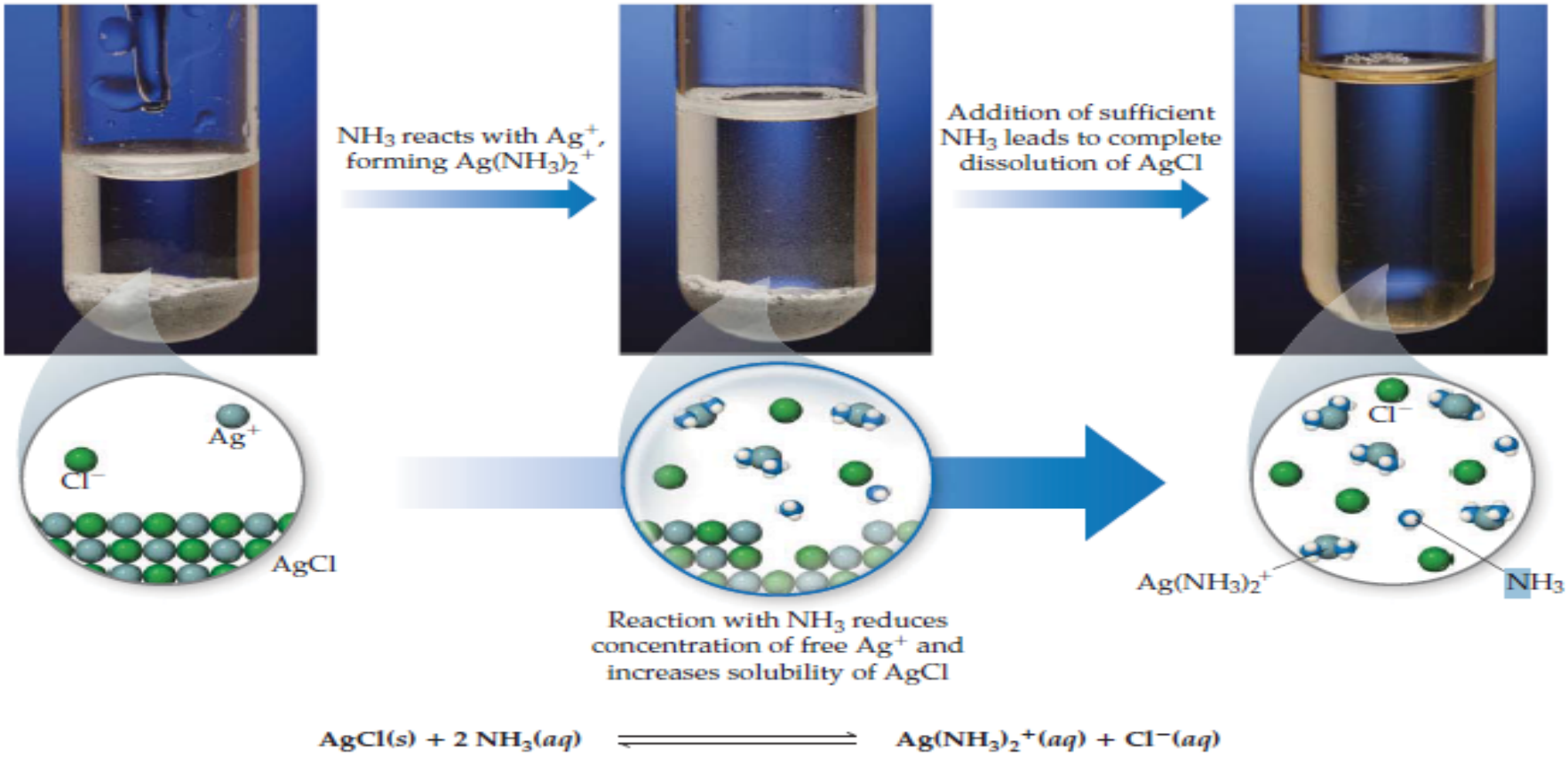
Salt Solubility & Formation of Complex Ions

$$AgCl(s) \rightleftharpoons Ag^+(aq) + Cl^-(aq) \quad [17.21]$$

$$Ag^+(aq) + 2\,NH_3(aq) \rightleftharpoons Ag(NH_3)_2{}^+(aq) \quad [17.22]$$

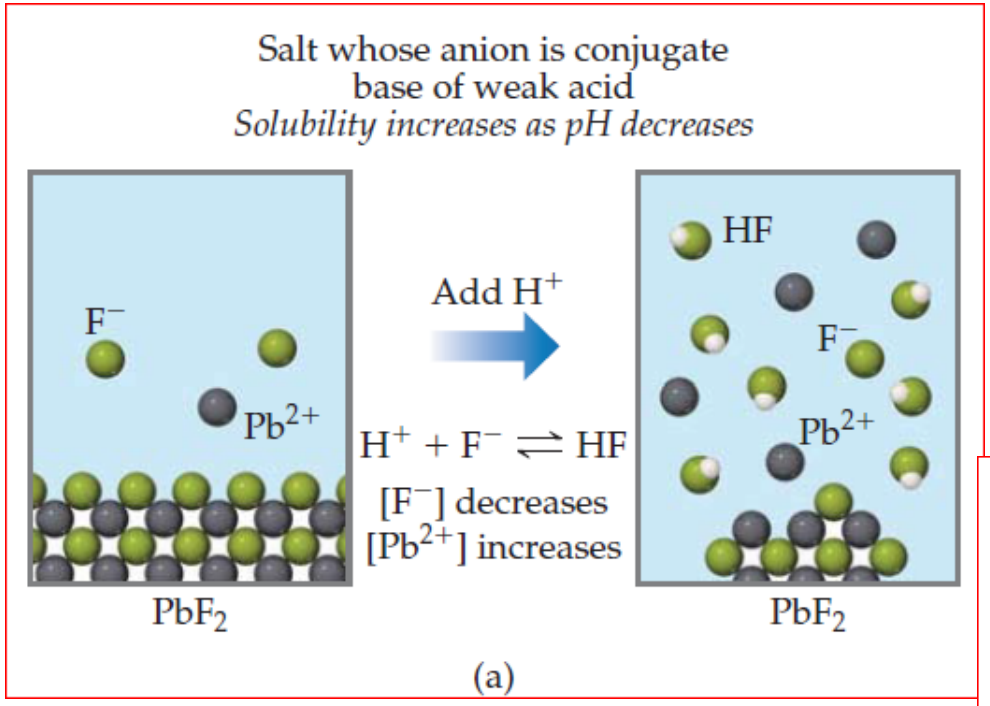
$$\text{Overall: } AgCl(s) + 2\,NH_3(aq) \rightleftharpoons Ag(NH_3)_2{}^+(aq) + Cl^-(aq) \quad [17.23]$$

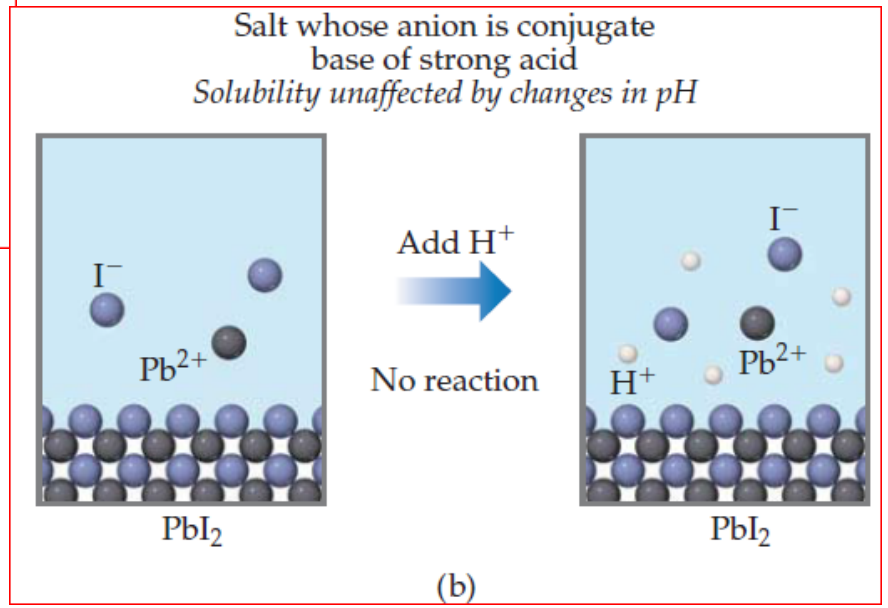
The presence of NH_3 drives the reaction, the dissolution of AgCl, to the right as $Ag^+(aq)$ is consumed to form $Ag(NH_3)_2{}^+$.



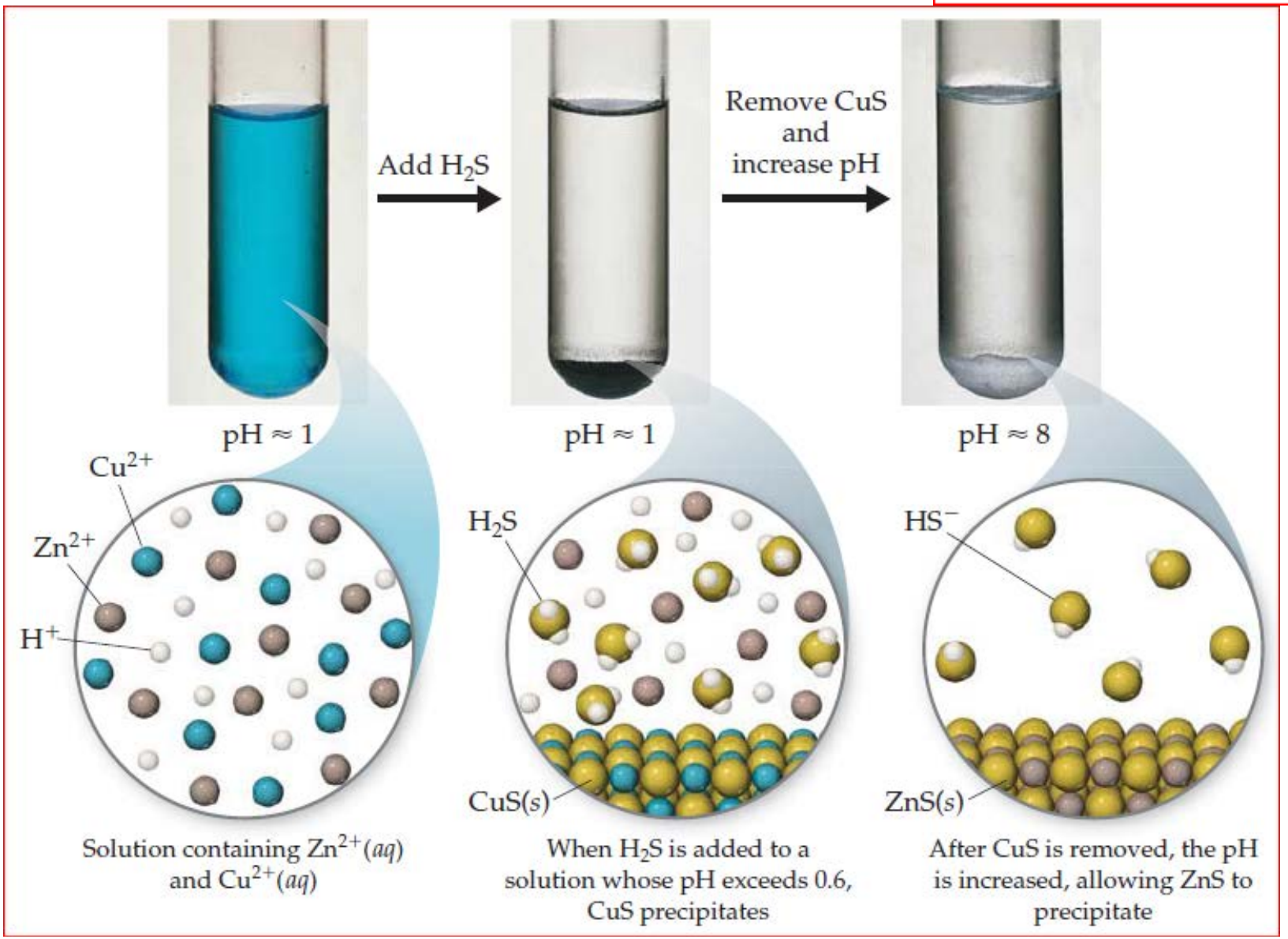
▲ **FIGURE 17.20** **Using concentrated $NH_3(aq)$ to dissolve AgCl(s), which has very low solubility in water.**

pH Effect on Solubility





What will happen when pH were raised to 8 first then H2S were added?



Selective precipitation. In this example Cu^{2+} ions are separated from Zn^{2+} ions.