Welcome to our CHEM 4 lecture

Review question: Balancing chemical reactions
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1) Solid iron(III) oxide reacts with carbon monoxide gas to produce iron metal and carbon dioxide gas. What is the coefficient in front of the carbon dioxide when this reaction is balanced?

A) 1 B) 2 C) 3 D) 4 E) 5 F) 6

Answer: _____ Fe_2O_3 (s) + _____ CO (g) → _____ Fe (s) + _____ CO_2 (g)

$$Fe_2O_3 \text{ (s)} + 3 \text{ CO (g)} \rightarrow 2 \text{ Fe (s)} + 3 \text{ } CO_2 \text{ (g)}$$

The next few weeks…

Week 13: November 23 (Monday)	November 25(Wednesday)	November 27 (Friday)

Before class:
• Read 7.8 [acid-base reactions] (*30 min*)
PAL worksheets for week 13: A and no PALs
 	
After class:
• Today's PowerPoint slides and recording *(45 min)*
• MasteringChemistry #28 (*20 min*) **[Due: M, 11/30]**
• You have from today until Dec 11 to complete your online CHEM 4 student evaluation. Here is a video explaining the process.
	No live lecture today
	In lieu of lecture:
	• No new reading, continue with 7.8 [gas forming reactions]
	• Asynchronous lecture: PowerPoint slides and recording *(45 min)*
	• MasteringChemistry: Assign #28a (*60 min*) **[Due: M, 11/30]**
	• Before class on **F, 12/11** is the last day to submit late homework for credit.
	• Prepare for our review session **[W, 12/2]** and Exam#3 **[F, 12/4].**
	  ◦ Learning outcomes for Exam #3
	  ◦ Practice: A, B, C and D *(50 min each)*
		No Class: Thanksgiving Holiday

Week 14: November 30 (Monday)	**December 2 (Wednesday)**	**December 4 (Friday)**
Before class: • Read 7.9-7.10 [types of reactions] (*1 hr*) **PAL worksheets for week 14:** A	**Before class:** • I'll spend the review session answering your questions from **Practice Exam #3** (A, B, C and D)	**Today in class: Exam #3 (in Canvas)** • Learning outcomes for Exam #3 • **Covers:** Cumulative, but stresses material since last exam (6.1-6.9, 3.7, 7.1-7.10). • **Practice**: A, B, C and D *(50 min each).(50 min each).*

After class:
• Today's PowerPoint slides and recording *(45 min)*
• MasteringChemistry #29 (*50 min*) **[Due: W, 4/29]**
• Prepare for our review session **[W, 12/2]** and Exam#3 **[F, 12/4].**
  ◦ Learning outcomes for Exam #3
  ◦ Practice: A, B, C and D *(50 min each)*
  ◦ Email Jeff (**jparadis@csus.edu**) with any practice exam questions you want him to go over during the review session on Wednesday. **Priority will be given to questions sent by 12 noon on Tuesday, Dec 1.**
	After class:
	• Finish preparing for Exam#3 **[F, 12/4].**
	  ◦ Learning outcomes for Exam #3
	  ◦ Practice: A, B, C and D *(50 min each)*
		After class:
		• Before class on **F, 12/11** is the last day to submit late homework for credit.
		• You have until Dec 11 to complete your online CHEM 4 student evaluation in Canvas. Here is a video explaining the process.

CHEM 4 lecture

Friday, November 20, 2020

Sec 7.5 – 7.7

Solubility rules, precipitation reactions, and Net Ionic Equations

Reading question: Solubility rules and precipitation reactions (Sec 7.5-7.7)
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2) Which of the following statements is false?

A) Making an aqueous solution involves dissolving a substance in water.

B) A precipitation reaction is when two aqueous solutions mix to form a solid.

C) All ionic compounds dissolve in water.

D) Solutions of strong electrolytes can conduct electricity.

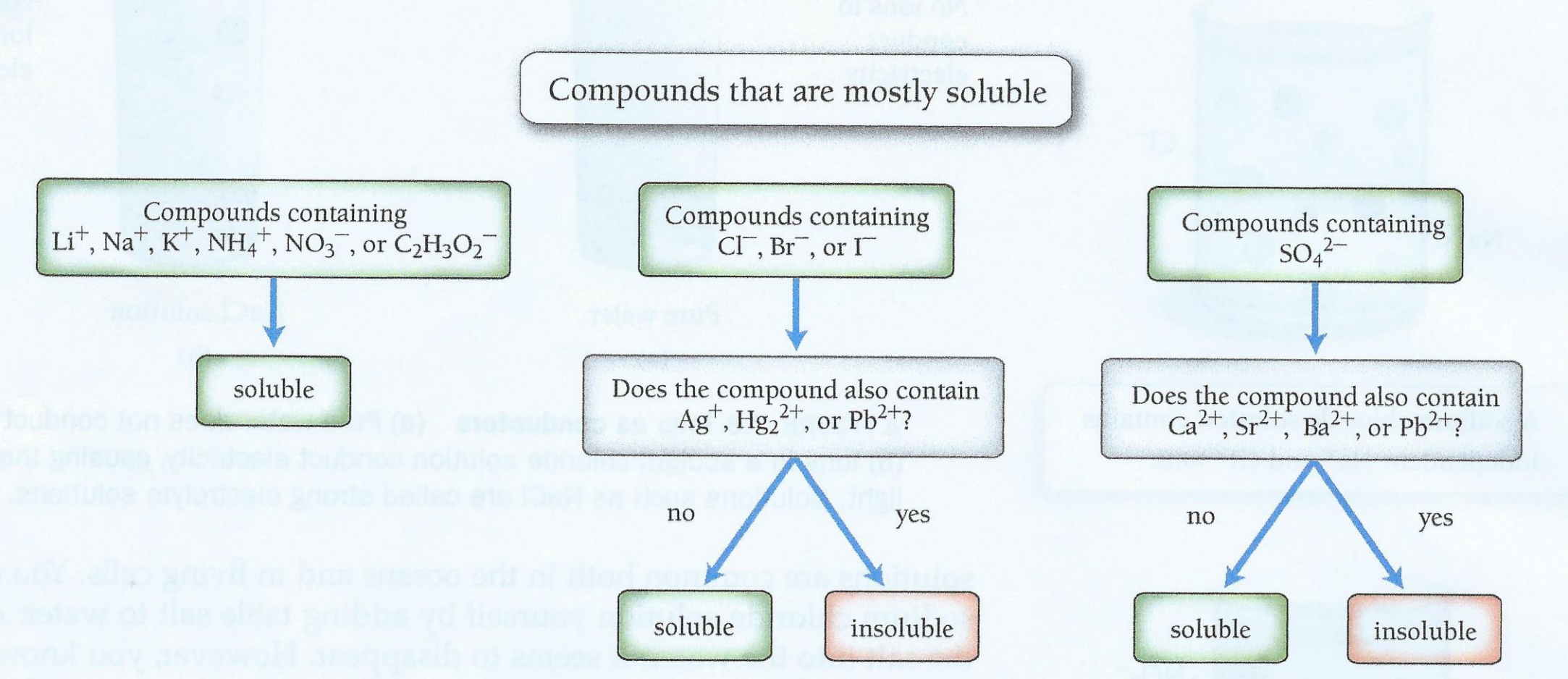
E) A net ionic equation is an equation showing only the species that actually participate in the reaction

F) Ions that do not participate in the reaction are called spectator ions.

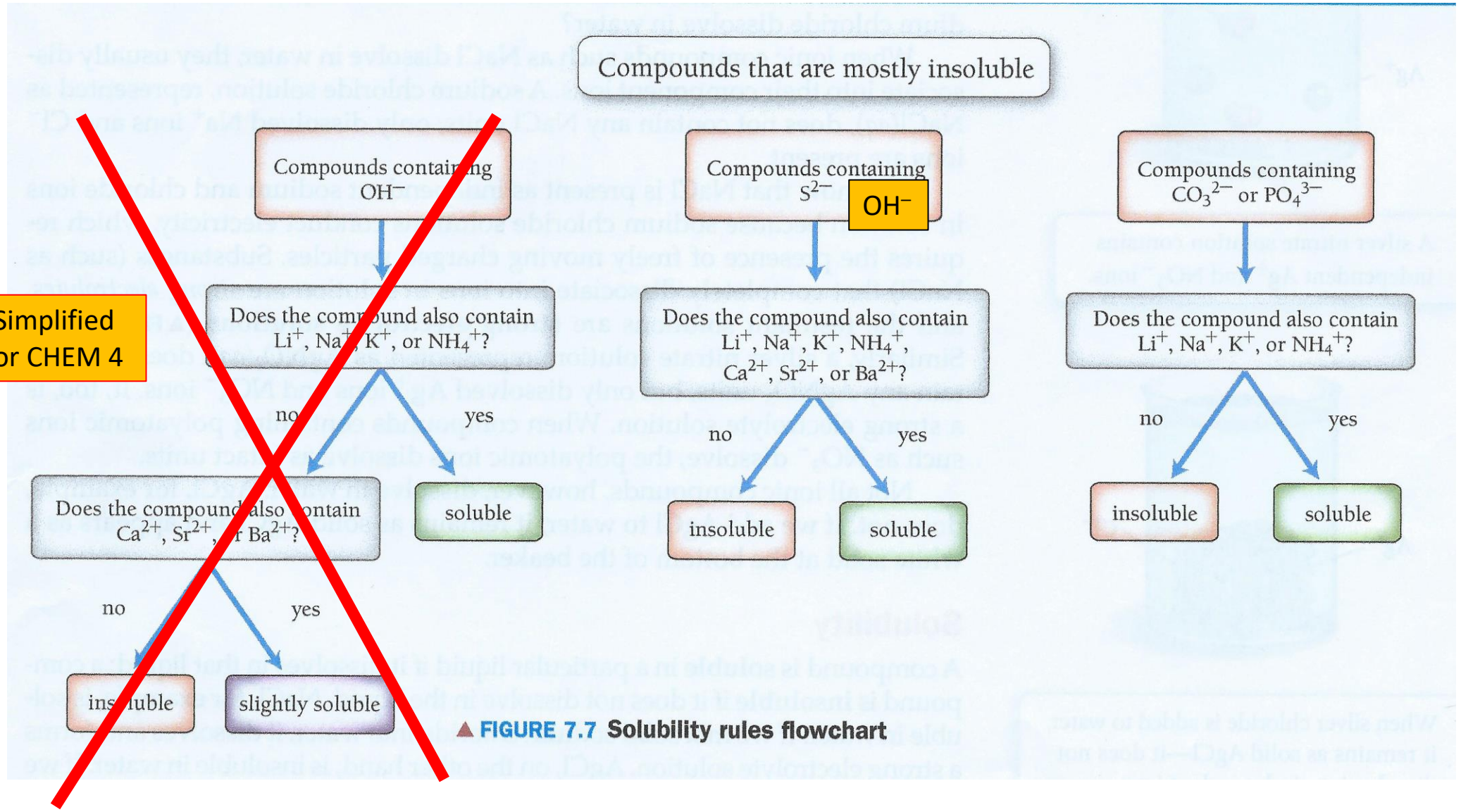
Background: Solubility rules

- Not all ionic compounds will dissolve in water. Those that dissolve are called **soluble**; those that don't dissolve are called **insoluble**.
- Determined experimentally by adding the solid to water and seeing if it dissolves.
- Luckily there are some patterns… for example, any compound that has Na^+ ions in it (think for example of NaCl, $NaNO_3$, Na_2CO_3, Na_3PO_4, NaOH…..) is found to be soluble in water.
- These patterns are summarized as a table of **solubility rules**.
- Rules can very slightly from textbook to textbook.
- Even "soluble" compounds have a limitation. For example, we say NaCl is soluble in water, but technically only 83.5 g of NaCl can dissolve in 100 g water at 60.2°C (notice the expected temperature dependence).

Important Solubility Rules for CHM 4, 1A/1B, and 1E



Important Solubility Rules for CHM 4, 1A/1B, and 1E



▲ FIGURE 7.7 Solubility rules flowchart

Important Solubility Rules for CHM 4, 1A/1B, and 1E

Soluble salts: → Labeled *(aq)* in chemical reactions. They are electrolytes.

- All Li^+, Na^+, K^+, and NH_4^+ → no exceptions
- All NO_3^- and $C_2H_3O_2^-$ → no exceptions
- All SO_4^{2-} → except: Ca^{2+}, Sr^{2+}, Ba^{2+}, Pb^{2+}
- All Cl^-, Br^-, and I^- → except: Ag^+, Pb^{2+}, Hg_2^{2+}

Insoluble salts: → Labeled *(s)* in chemical reactions.

- All PO_4^{3-} and CO_3^{2-} → except: Li^+, Na^+, K^+, and NH_4^+
- All OH^- and S^{2-} → except: Li^+, Na^+, K^+, NH_4^+, Ca^{2+}, Sr^{2+}, and Ba^{2+}

Clicker question: Using solubility rules
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3) Using the solubility guidelines, which of the following compounds would be expected to be insoluble in water?

A) $Sr(OH)_2$ C) Na_2SO_4 E) $Pb(NO_3)_2$

B) CaS D) $BaSO_4$ F) Li_2CO_3

Soluble salts:

- All Li^+, Na^+, K^+, and NH_4^+ → no exceptions
- All NO_3^- and $C_2H_3O_2^-$ → no exceptions
- All SO_4^{2-} → except: Ca^{2+}, Sr^{2+}, Ba^{2+}, Pb^{2+}
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Insoluble salts:

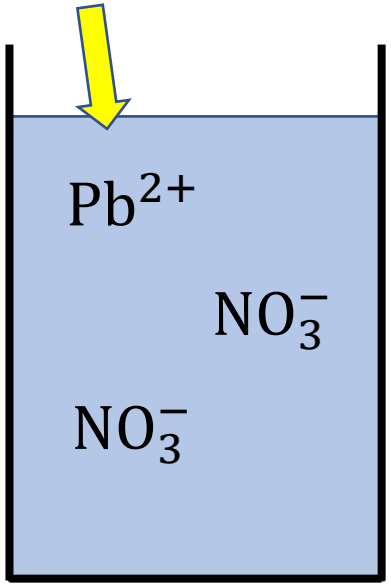
- All PO_4^{3-} and CO_3^{2-} → except: Li^+, Na^+, K^+, and NH_4^+
- All OH^- and S^{2-} → except: Li^+, Na^+, K^+, NH_4^+, Ca^{2+}, Sr^{2+}, and Ba^{2+}

Drawings based on solubility rules

Be able to use solubility rules to draw representations of various compounds in water.

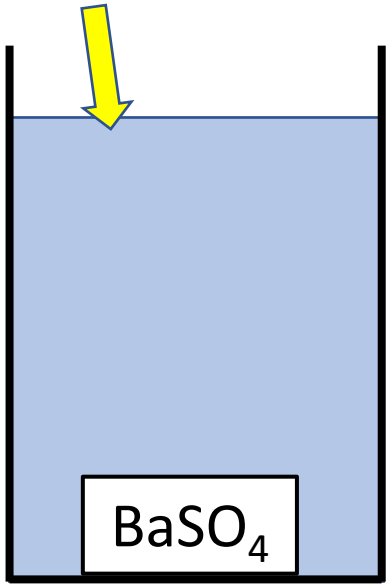
Examples:

$Pb(NO_3)_2$ = soluble



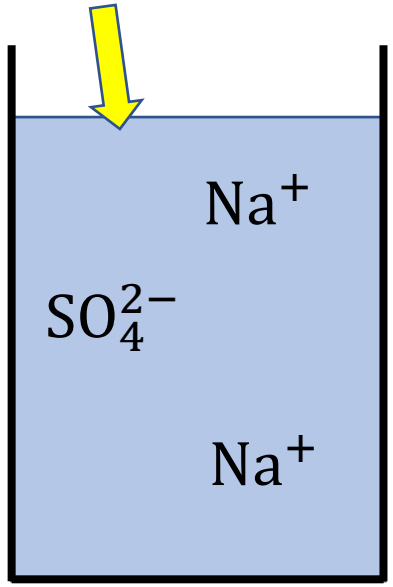
$Pb(NO_3)_2$ *(aq)*

$BaSO_4$ = insoluble



$BaSO_4$ *(s)*

Na_2SO_4 = soluble



Na_2SO_4 *(aq)*

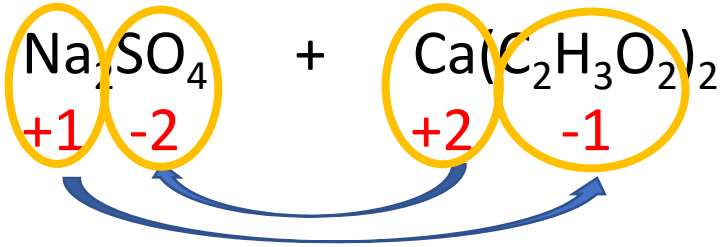
Drawings should have the right ions with the right charges, in the right ratio. In the last example, you could draw 2 x SO_4^{2-} ions, but would also have to draw 4 x Na^+ ions.

Sample problem: Writing Net Ionic Equations (**NIE**)

Ex: Write the NIE for the **precipitation reaction** between sodium sulfate and calcium acetate

When two (aq) solutions combine to form a (s). Abbreviation = PPT rxn

1) Write the formula for the reactants and label the ion charges:



2) Predict the products by switching the pairs of ions. This is done by taking the cation from one reactant and pairing it with the anion from the other reactant. Remember the cation always goes first and don't worry about how many of each ion you started with… focus on balancing the charges in the products:

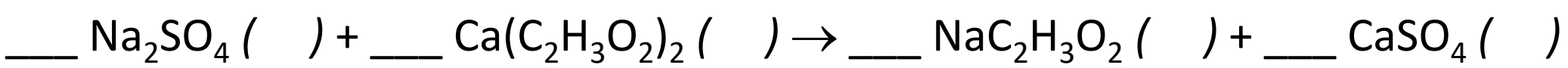
Na^+ will pair up with $C_2H_3O_2^-$ to make $NaC_2H_3O_2$

Ca^{2+} will pair up with SO_4^{2-} to make $CaSO_4$

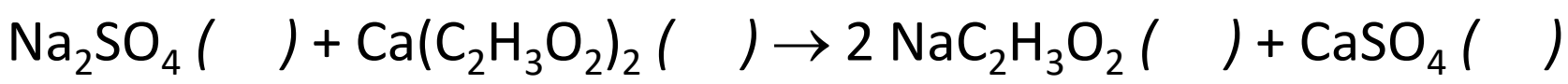
Sample problem continued… Writing Net Ionic Equations (**NIE**)

Ex: Write the NIE for the reaction between sodium sulfate and calcium acetate

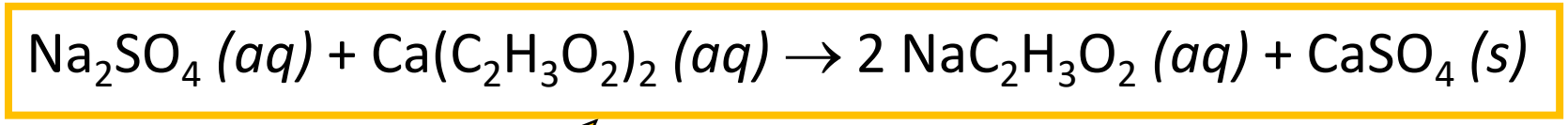
3) Write out the reaction leaving spaces to balance and add states:



4) Balance the reaction:



5) Predict the states using solubility rules. If soluble = *(aq)*, if insoluble = *(s)*



This is the **molecular equation**.

Sample problem continued… Writing Net Ionic Equations (**NIE**)

Ex: Write the NIE for: $Na_2SO_4\ (aq) + Ca(C_2H_3O_2)_2\ (aq) \rightarrow 2\ NaC_2H_3O_2\ (aq) + CaSO_4\ (s)$

6) Break *(aq)* into ions. Leave *(s)*, *(l)*, and *(g)* together:

$$2\ Na^+(aq) + SO_4^{2-}(aq) + Ca^{2+}(aq) + 2\ C_2H_3O_2^-(aq) \rightarrow 2\ Na^+(aq) + 2\ C_2H_3O_2^-(aq) + CaSO_4(s)$$

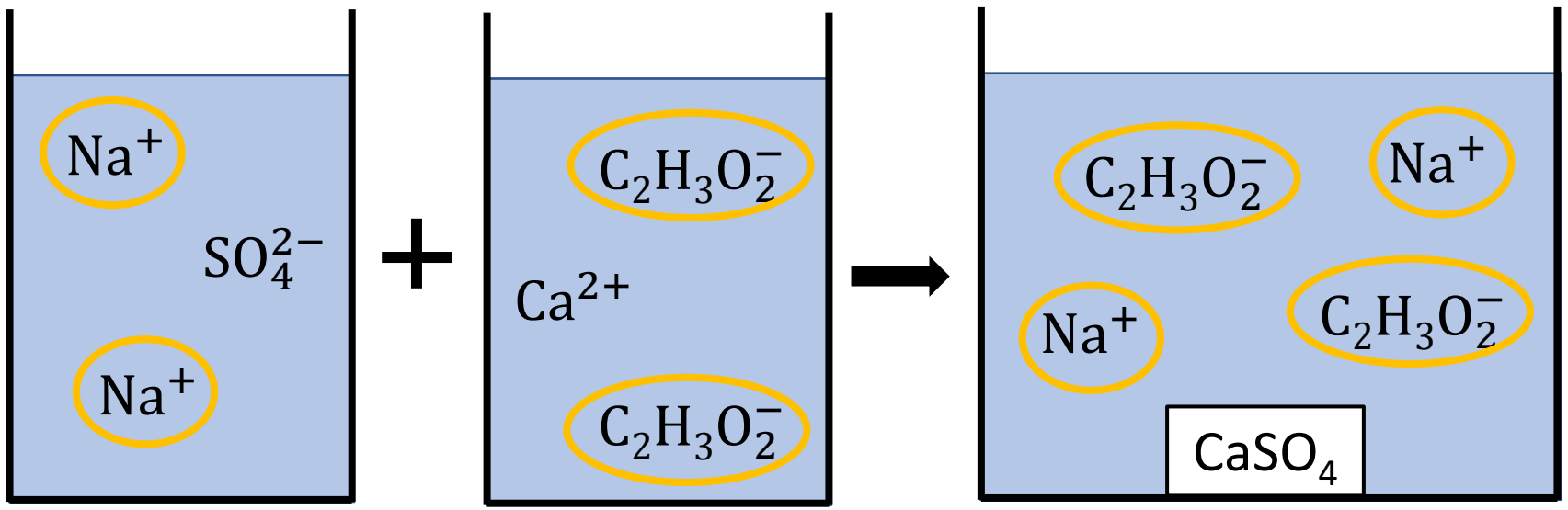
This is the **complete ionic equation**. It gives us a more realistic version of what is really happening in the water.

Sample problem continued… Writing Net Ionic Equations (**NIE**)

Ex: Write the NIE for:

$2\ Na^+(aq) + SO_4^{2-}(aq) + Ca^{2+}(aq) + 2\ C_2H_3O_2^-(aq) \rightarrow 2\ Na^+(aq) + 2\ C_2H_3O_2^-(aq) + CaSO_4(s)$

7) Optional step: Be able to draw representations of the complete ionic reaction



In both the complete ionic reaction and in our drawing, we see ions that are identical on both sides of the reaction. These are **spectator ions** and are not involved in the actual chemistry.

Sample problem continued… Writing Net Ionic Equations (**NIE**)

Ex: *Write the NIE for the reaction between sodium sulfate and calcium acetate*

$2\ Na^{+}(aq) + SO_4^{2-}(aq) + Ca^{2+}(aq) + 2\ C_2H_3O_2^{-}(aq) \rightarrow 2\ Na^{+}(aq) + 2\ C_2H_3O_2^{-}(aq) + CaSO_4(s)$

8) Cancel out the spectator ions. Gives:

$$SO_4^{2-}(aq) + Ca^{2+}(aq) \rightarrow CaSO_4(s)$$

This is the **net ionic equation (NIE)**. It allows us to focus on the most important chemistry that is occuring.

Clicker question: Balancing a chemical reaction
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4) What is/are the product(s) in net ionic equation (NIE) when aqueous solutions of calcium hydroxide and tin(IV) nitrate are combined?

A) $2Ca(NO_3)_2(aq) + Sn(OH)_4(s)$
B) $2Ca^{2+}(aq) + 4NO_3^-(aq) + Sn(OH)_4(s)$
C) $Sn(OH)_4(s)$
D) $2Ca(NO_3)_2(s) + Sn(OH)_4(aq)$
E) $2Ca(NO_3)_2(s) + Sn^{4+}(aq) + 4OH^-(aq)$
F) $Ca(NO_3)_2(s)$

Answer:

- **Molecular:**

  $2Ca(OH)_2(aq) + Sn(NO_3)_4(aq) \rightarrow 2Ca(NO_3)_2(aq) + Sn(OH)_4(s)$

- **Complete ionic:**

  $2Ca^{2+}(aq) + 4OH^-(aq) + Sn^{4+}(aq) + 4NO_3^-(aq) \rightarrow 2Ca^{2+}(aq) + 4NO_3^-(aq) + Sn(OH)_4(s)$

- **Net ionic:**

  $4OH^-(aq) + Sn^{4+}(aq) \rightarrow Sn(OH)_4(s)$