Chemical Reactions: Precipitates & Solubility

# **Purpose** To investigate a series of chemical reactions related to the solubility of various compounds. This will render practice in writing and balancing chemical reactions, naming chemical formulas, and discovering if and when precipitates form, all based on real reagents combining to form real products.

**Background** One of two things can happen when aqueous solutions of two different ionic compounds are mixed. If none of the ions combine to form a compound, then the solution will remain clear because the ions remain dissolved in solution (aqueous).

However, sometimes a solid is formed and will separate from the solution. This solid substance, called a **precipitate**, is formed when two oppositely charged ions are attracted to one another and bond together to form an ionic compound that is **insoluble** **in water**. This is called a double displacement reaction or an ion-exchange reaction.

If no precipitate forms, meaning that the chemical reagents simply remained soluble in water, then only a physical change occurs (dissociation). One can represent this using (aq) after the compound. The (aq) indicates that the compound is dissolved in water (aqueous).

When a chemical reaction does take place because a precipitate forms, one can indicate the precipitate by using a downward arrow [**↓**] or a subscript [ (**s**) ] after the product that is insoluble. For example:

3Pb(NO3)2 (aq) + 2Na3(PO4) (aq) 🡪 Pb3(PO4)2  **↓** + NaNO3 (aq)

2AgNO3 (aq) + Na2CO3 (aq) 🡪 Ag2CO3 (**s**) + 2NaNO3 (aq)

**Materials** Videos & Lab Document

**Procedures**

1. CHOICE: You can either watch the videos on the Double Displacement Reactions Labs and complete the Calculations and Data (table, equations) and Conclusions OR go to page 6 and use the data table answers as a base to complete the lab.

a) The 1st – 3rd videos show the reactions (very cool!)

b) The last two videos go over two of the reactions: how to write and balance the equations, writing the net ionic equation, and showing spectator ions.

2. Complete the data chart based on the videos or use the answer key on page 6.

3. Complete the equation sheet for **TEN (10)** of the equations. Answers are provided at the end for guidance.

4. Once you have completed as much as you wanted, go to Study Place and fill out the Poll.

*This is great practice in writing and balancing the equations for the double replacement reactions and considering solubility of various ionic compounds.*

**Calculations and Data** *Record data on the following pages*.

1. Complete the “**Reaction Table**” on your Calculations and Data sheet as you proceed through all 49 mixtures of this lab OR use the answers on page 6.
2. Write **Balanced equations** for the TEN (10) mixtures (boldfaced on equation sheet) by completing and balancing the equations on your Calculations and Data sheet.
3. **Indicate any precipitate** that formed using a down arrow [ **↓** ] or a symbol [ *(s)* ] just to the right of the precipitate in your balanced equation (*as shown in the discussion section*). Use Reference Table 1, Chart E for help. All ionic compounds in this lab are dissolved in water (aqueous) and should have the symbol [ *(aq)* ] just to the right of the compound.
4. For the reactions that produced a precipitate, **name all the reactant compounds and product compounds** using the rules we discussed in class. Write these names directly below each reactant and product on your Calculations and Data sheet.

**Conclusions and Questions**

1. Complete the table called “Solubility Rules for the Solubility of Salts in Water” shown on the following pages. The answer key is provided for guidance.

2. For any **TWO** of the precipitated reactions from this lab, show the net ionic equation and the spectator ions involved. Do this on the equations page.

* ***Use Reference Table 1, Chart E “Table of Solubilities in Water” to confirm your results.***
* The following videos show the EXPERIMENT (combining compounds).  
    
  [Silver Nitrate combining with ionic compounds](http://somup.com/cFXnDqn1bc) (2:29)  
    
  [Barium Nitrate, CobaltII Nitrate, and CopperII Nitrate combining with ionic compounds](http://somup.com/cFXnbJn1bK) (3:32)  
    
  [IronIII Nitrate, LeadII Nitrate, and Potassium Nitrate combining with ionic compounds](https://screencast-o-matic.com/watch/cFXnrdYshI) (2:30)

1. REACTION TABLE

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Solution Set B** | | | | | | |
| **Solution**  **Set A ↓** | Zn(C2H3O2)2 (aq) | NaI(aq) | Na2(CO3)2(aq) | Na3(PO4) (aq) | Na2(SO4) (aq) | NaOH(aq) | NaCl(aq) |
|  |  |  |  |  |  |  |  |
| Ag(NO3) (aq) |  |  |  |  |  |  |  |
| Ba(NO3)2(aq) |  |  |  |  |  |  |  |
| Co(NO3)2(aq) |  |  |  |  |  |  |  |
| Cu(NO3)2(aq) |  |  |  |  |  |  |  |
| Fe(NO3)3 (aq) |  |  |  |  |  |  |  |
| Pb(NO3)2 (aq) |  |  |  |  |  |  |  |
| K(NO3) (aq) |  |  |  |  |  |  |  |

2. Write **Balanced equations** for the reactions that formed precipitates. *Complete the equations ONLY for the reactions that formed precipitates:*

1. AgNO3 (aq) + Zn (C2H3O2)2 (aq) →

2. AgNO3 (aq) + NaI (aq) →

**3. AgNO3** (aq) **+ Na2CO3** (aq) **→**

4. AgNO3 (aq) + Na3PO4 (aq)  →

5. AgNO3 (aq) + Na2SO4 (aq) →

**6. AgNO3** (aq) **+ NaOH** (aq) **→**

7. AgNO3 (aq) + NaCl (aq) →

8. Ba(NO3)2 (aq) + Zn(C2H3O2)2 (aq) →

9. Ba(NO3)2 (aq) + 2NaI (aq) →

**10. Ba(NO3)2** (aq) **+ Na2CO3** (aq) **→**

**11. Ba(NO3)2** (aq) **+ Na3PO4** (aq) **→**

12. Ba(NO3)2 (aq) + Na2SO4 (aq) →

13. Ba(NO3)2 (aq) + NaOH (aq) →

14. Ba(NO3)2 (aq) + NaCl (aq) →

15. Co(NO3)2 (aq) + Zn(C2H3O2)2 (aq) →

16. Co(NO3)2 (aq) + NaI (aq) →

**17. Co(NO3)2** (aq) **+ Na2CO3** (aq) **→**

18. Co(NO3)2 (aq) + Na3PO4 (aq) →

19. Co(NO3)2 (aq) + Na2SO4 (aq)  →

20. Co(NO3)2 (aq) + NaOH (aq) →

21. Co(NO3)2 (aq) + NaCl (aq) →

22. Cu(NO3)2 (aq) + Zn(C2H3O2)2 (aq) →

**23. Cu(NO3)2** (aq) **+ NaI** (aq) **→**

24. Cu(NO3)2 (aq) + Na2CO3 (aq) →

**25. Cu(NO3)2** (aq) **+ Na3PO4** (aq) **→**

26. Cu(NO3)2 (aq) + Na2SO4 (aq) →

27. Cu(NO3)2 (aq) + NaOH (aq) →

28. Cu(NO3)2 (aq) + NaCl (aq) →

29. Fe(NO3)3 (aq) + Zn(C2H3O2)2 (aq) →

30. Fe(NO3)3 (aq) + NaI (aq) →

**31. Fe(NO3)3** (aq) **+ Na2CO3** (aq) **→**

**32. Fe(NO3)3** (aq) **+ Na3PO4** (aq) **→**

33. Fe(NO3)3 (aq) + Na2SO4 (aq) →

34. Fe(NO3)3 (aq) + NaOH (aq) →

35. Fe(NO3)3 (aq) + NaCl (aq) →

36. Pb(NO3)2 (aq) + Zn(C2H3O2)2 (aq) →

37. Pb(NO3)2 (aq) + NaI (aq) →

38. Pb(NO3)2 (aq) + Na2CO3 (aq) →

39. Pb(NO3)2 (aq) + Na3PO4 (aq) →

40. Pb(NO3)2 (aq) + Na2SO4 (aq) →

41. Pb(NO3)2 (aq) + NaOH (aq) →

42. Pb(NO3)2 (aq) + NaCl (aq) →

43. KNO3 (aq) + Zn(C2H3O2)2 (aq) →

44. KNO3 (aq) + NaI (aq) →

45. KNO3 (aq) + Na2CO3 (aq) →

46. KNO3 (aq) + Na3PO4 (aq) →

47. KNO3 (aq) + Na2SO4 (aq) →

48. KNO3 (aq) + NaOH (aq) →

49. KNO3 (aq) + NaCl (aq) →

**Conclusions and Questions**

1. Complete the table called “Solubility Rules for the Solubility of Salts in Water” shown on the next page. The answer key is provided for guidance.

* ***Use Reference Table 1, Chart E “Table of Solubilities in Water” to confirm your results.***

Solubility Rules for the Solubility of Salts in Water

|  |  |  |
| --- | --- | --- |
| **Ion** | **Soluble or Insoluble?** | **Exceptions** |
| -NO3-1 |  | None |
| -C2H3O2-1 |  | Ag+1 Fe+3 |
| -CO3-2 |  | Na+1 K+1 |
| -PO4-3 |  | Na+1 K+1 Ba+1 Co+2 |
| -SO4-2 |  | Ba+2 Pb+2 |
| -OH-1 |  | Na+1, K+1, and Ba+2 |
| -I-1 |  | Pb+2 and Ag+1 |
| -Cl-1 |  | Pb+2 and Ag+1 |
| -Na+1 |  | None |
| -K+1 |  | None |

2. For any **TWO** of the precipitated reactions from this lab, show the net ionic equation and the spectator ions involved. Do this on the equations page.

Answers for Chemical Reactions Lab

REACTION TABLE

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Solution Set B** | | | | | | |
| **Solution**  **Set A ↓** | Zn(C2H3O2)2 (aq) | NaI(aq) | Na2(CO3)2(aq) | Na3(PO4) (aq) | Na2(SO4) (aq) | NaOH(aq) | NaCl(aq) |
|  |  |  |  |  |  |  |  |
| Ag(NO3) (aq) | White  ss | Yellow | White | Bright yellow | Aq | Whitish yellow | White |
| Ba(NO3)2(aq) | Aq | Aq | White | Aq | White | Aq | Aq |
| Co(NO3)2(aq) | Aq | Aq | Blue | Aq | Aq | Blue | Aq |
| Cu(NO3)2(aq) | Aq | Brown | Light blue | Light blue | Aq | Blue | Aq |
| Fe(NO3)3 (aq) | Aq  Red | Aq  Black | Orange | White | Aq | Red | Aq |
| Pb(NO3)2 (aq) | Aq | Yellow ss | White | White | White | White | White ss |
| K(NO3) (aq) | Aq | Aq | Aq | Aq | Aq | Aq | Aq |

###### Balanced Equations (*with net ionic equations & spectator ions*)

### 23 reactions formed precipitates

1. 2Ag+1NO3-1 (aq) + Zn+2(C2H3O2) -12 (aq) → 2Ag+1C2H3O2-1 ↓ + Zn+2(NO3) -12 (aq)

Silver Nitrate Zinc Acetate Silver I Acetate ZincII Nitrate

Ag+1(aq) + (C2H3O2)-1(aq) → Ag(C2H3O2) (s) Zn+2(aq) , NO3-1(aq)

***Silver is a transition element (group B), but only has ONE oxidation state (Ag+). Therefore, it can be named as a typical metal “silver”. Zinc is a transition element (group B), but only has ONE oxidation state (Zn+2). Therefore, it can be named as a typical metal “zinc”.***

2. Ag+1NO3-1 (aq) + Na+1I-1 (aq) → Ag+1I-1 ↓ + Na+1NO3-1 (aq)

Silver I Nitrate Sodium Iodide Silver I Iodide Sodium Nitrate

Ag+1 (aq) + I-1 (aq) → AgI (s) Na+1 (aq) , NO3-1 (aq)

**3. 2Ag+1NO3-1** (aq) **+ Na2+1CO3-2** (aq) **→ Ag2+1CO3-2↓ + 2Na+1NO3-1** (aq)

**Silver I Nitrate Sodium Carbonate Silver I Carbonate Sodium Nitrate**

**2Ag+1** (aq) **+ CO3-2** (aq) **→ Ag2CO3 (s) 2Na+1** (aq) **, 2NO3-1** (aq)

4. 3Ag+1NO3-1 (aq) + Na3+1PO4-3 (aq)  → Ag3+1PO4-3↓ + 3Na+1NO3-1 (aq)

Silver I Nitrate Sodium Phosphate Silver I Phosphate Sodium Nitrate

3Ag+1 (aq) + PO4-3 (aq) → Ag3PO4 (s) 3Na+1 (aq) , 3NO3-1 (aq)

5. AgNO3 (aq) + Na2SO4 (aq) → aqueous

**6. Ag+1NO3-1** (aq) **+ Na+1OH-1** (aq) **→ Ag+1 (OH) -1 ↓ + Na+1NO3-1** (aq)

Silver I Nitrate Sodium Hydroxide Silver I Hydroxide Sodium Nitrate

**Ag+1** (aq) **+ OH-1** (aq) **→ AgOH (s) Na+1** (aq)**, NO3-1** (aq)

7. Ag+1NO3-1 (aq) + Na+1Cl-1 (aq) → Ag+1Cl-1 ↓ + Na+1NO3-1 (aq)

Silver I Nitrate Sodium Chloride Silver I Chloride Sodium Nitrate

2Ag+1 (aq) + Cl-1 (aq) → AgCl (s) 2Na+1 (aq), 2NO3-1 (aq)

8. Ba(NO3)2 (aq) + Zn(C2H3O2)2 (aq) → aqueous

9. Ba(NO3)2 (aq) + 2NaI (aq) → aqueous

**10. Ba+2(NO3) -12** (aq) **+ Na2+1CO3-2** (aq) **→ Ba+2CO3-2↓+ 2Na+1NO3-1** (aq)

**Barium Nitrate Sodium Carbonate Barium Carbonate Sodium Nitrate**

**Ba+2** (aq) **+ CO3-2** (aq) **→ BaCO3 (s) 2Na+1** (aq)**, 2NO3-1** (aq)

**11. 3Ba+2(NO3)2** (aq) **+ 2Na3+1PO4** (aq) **→ Ba3+2(PO4)2 ↓ + 6Na+1NO3** (aq)

**Barium Nitrate Sodium Phosphate Barium Phosphate Sodium Nitrate**

**3Ba+2** (aq) **+ 2PO4-3** (aq) **→ Ba3(PO4)2 (s) 6Na+1** (aq)**, 6NO3-1** (aq)

12. Ba+2(NO3) -12 (aq) + Na2+1SO4-2 (aq) → Ba+2SO4-2 ↓ + 2Na+1NO3-1 (aq)

Barium Nitrate Sodium Sulfate Barium Sulfate Sodium Nitrate

Ba+2 (aq) + SO4-2 (aq) → Ba(SO4) (s) 2Na+1 (aq), 2NO3-1 (aq)

13. Ba(NO3)2 (aq) + 2NaOH (aq) → aqueous

14. Ba(NO3)2 (aq) + 2NaCl (aq) → aqueous

15. Co(NO3)2 (aq) + Zn(C2H3O2)2 (aq) → aqueous

16. Co(NO3)2 (aq) + 2NaI (aq) → aqueous

**17. Co+2(NO3) -12** (aq) **+ Na2+1CO3-2** (aq) **→ Co+2CO3-2 ↓ + 2Na+1NO3-1** (aq)

**Cobalt II Nitrate Sodium Carbonate Cobalt II Carbonate Sodium Nitrate**

**Cobaltous Nitrate Sodium Carbonate Cobaltous Carbonate Sodium Nitrate**

**Co+2** (aq) **+ CO3-2** (aq) **→ CoCO3 (s) 2Na+1** (aq)**, 2NO3-1** (aq)

18. 3Co(NO3)2 (aq)  + 2Na3PO4 (aq) → aqueous

19. Co(NO3)2 (aq) + Na2SO4 (aq)  → aqueous

20. Co+2(NO3) -12 (aq) + 2Na+1OH-1 (aq) → Co+2(OH) -12 ↓ + 2Na+1NO3-1 (aq)

Cobalt II Nitrate Sodium Hydroxide Cobalt II Hydroxide Sodium Nitrate

Cobaltous Nitrate Sodium Hydroxide Cobaltous Hydroxide Sodium Nitrate

Co+2 (aq) + 2OH-1 (aq) → Co(OH)2 (s) 2Na+1 , 2NO3-1 (aq)

21. Co(NO3)2 (aq) + 2NaCl (aq) → aqueous

22. Cu(NO3)2 (aq) + Zn(C2H3O2)2 (aq) → aqueous

**23. Cu+2(NO3)-12** (aq) **+ 2Na+1I-1** (aq) **→ Cu+2I-12 ↓ + 2Na+1NO3-1** (aq)

**Copper II Nitrate Sodium Iodide Copper II Iodide Sodium Nitrate**

**Cupric Nitrate Sodium Iodide Cupric Iodide Sodium Nitrate**

**Cu+2** (aq) **+ CO3-2** (aq) **→ CuCO3 (s) 2Na+1** (aq)**, 2NO3-1** (aq)

24. Cu+2(NO3) -12 (aq) + Na2+1CO3-2 (aq) → Cu+2CO3-2↓ + 2Na+1NO3-1 (aq)

Copper II Nitrate Sodium Carbonate Copper II Carbonate Sodium Nitrate

Cupric Nitrate Sodium Carbonate Cupric Carbonate Sodium Nitrate

Cu+2 (aq) + CO3-2 (aq) → CuCO3 (s) 2Na+1 (aq), 2NO3-1 (aq)

**25. 3Cu+2(NO3)-12** (aq) **+ 2Na3+1PO4-3** (aq) **→ Cu3+2(PO4)-32 ↓ + 6Na+1NO3-1** (aq)

**Copper II Nitrate Sodium Phosphate Copper II Phosphate Sodium Nitrate**

**Cupric Nitrate Sodium Phosphate Cupric Phosphate Sodium Nitrate**

**Cu+2** (aq) **+ PO4-3** (aq) **→ Cu3(PO4)2 (s) 6Na+1** (aq)**, 6NO3-1** (aq)

26. Cu(NO3)2 (aq) + Na2SO4 (aq) → aqueous

27. Cu+2(NO3)-12 (aq) + 2Na+1OH-1 (aq) → Cu+2(OH)-12 ↓ + 2Na+1NO3-1 (aq)

Copper II Nitrate Sodium Hydroxide Copper II Hydroxide Sodium Nitrate

Cupric Nitrate Sodium Hydroxide Cupric Hydroxide Sodium Nitrate

Cu+2 (aq) + OH-1 (aq) → Cu(OH)2 (s) 2Na+1 (aq), 2NO3-1 (aq)

28. Cu(NO3)2 (aq) + 2NaCl (aq) → aqueous

29. 2Fe(NO3)3 (aq) + 3Zn(C2H3O2)2 (aq) → aqueous

30. Fe(NO3)3 (aq) + 3NaI (aq) → aqueous

**31. 2Fe+3(NO3)-13** (aq) **+ 3Na2+1CO3-2** (aq) **→ Fe2+3(CO3)-23 ↓ + 6Na+1NO3-1** (aq)

**Iron III Nitrate Sodium Carbonate Iron III Carbonate Sodium Nitrate**

**Ferric Nitrate Sodium Carbonate Ferric Carbonate Sodium Nitrate**

**Fe+3** (aq) **+ CO3-2** (aq) **→ Fe2(CO3)3 (s) 6Na+1** (aq)**, 6NO3-1** (aq)

**32. Fe+3(NO3)-13** (aq) **+ Na3+1PO4-3** (aq) **→ Fe+3PO4-3↓ + 3Na+1NO3-1** (aq)

**Iron III Nitrate Sodium Phosphate Iron III Phosphate Sodium Nitrate**

**Ferric Nitrate Sodium Phosphate Ferric Phosphate Sodium Nitrate**

**Fe+3** (aq) **+ PO4-3** (aq) **→ FePO4 (s) 3Na+1** (aq)**, 3NO3-1** (aq)

33. 2Fe(NO3)3 (aq) + 3Na2SO4 (aq) → aqueous

34. Fe+3(NO3)-13 (aq) + 3Na+1OH-1 (aq) → Fe+3(OH)-13 ↓ + 3Na+1NO3-1 (aq)

Iron III Nitrate Sodium Hydroxide Iron III Hydroxide Sodium Nitrate

Ferric Nitrate Sodium Hydroxide Ferric Hydroxide Sodium Nitrate

Fe+3 (aq) + OH-1 (aq) → Fe(OH)3 (s) 3Na+1 (aq), 3NO3-1 (aq)

35. Fe(NO3)3 (aq) + 3NaCl (aq) → aqueous

36. Pb(NO3)2 (aq) + Zn(C2H3O2)2 (aq) → aqueous

37. Pb+2(NO3)-12 (aq) + 2Na+1I-1 (aq) → Pb+2I-12 ↓ + 2Na+1NO3-1 (aq)

Lead II Nitrate Sodium Iodide Lead II Iodide Sodium Nitrate

Pb+2 (aq) + I-1 (aq) → PbI2 (s) 2Na+1 (aq), 2NO3-1 (aq)

38. Pb+2(NO3)-12 (aq) + Na2+1CO3-2 (aq) → Pb+2CO3-2↓ + 2Na+1NO3-1 (aq)

Lead II Nitrate Sodium Carbonate Lead II Carbonate Sodium Nitrate

Pb+2 (aq) + CO3-2 (aq) → Pb(CO3) (s) 2Na+1 (aq), 2NO3-1 (aq)

39. 3Pb+2(NO3)-12 (aq) + 2Na3+1PO4-3 (aq) → Pb3+2(PO4)-32 ↓ + 6Na+1NO3-1 (aq)

Lead II Nitrate Sodium Phosphate Lead II Phosphate Sodium Nitrate

Pb+2 (aq) + PO4-3 (aq) → Pb2(PO4)3 (s) 6Na+1 (aq), 6NO3-1 (aq)

40. Pb+2(NO3)-12 (aq) + Na2+1SO4-2 (aq) → Pb+2SO4-2 ↓ + 2Na+1NO3-1 (aq)

Lead II Nitrate Sodium Sulfate Lead II Sulfate Sodium Nitrate

Pb+2 (aq) + SO2-2 (aq) → PbSO4 (s) 2Na+1 (aq), 2NO3-1 (aq)

41. Pb+2(NO3)-12 (aq) + 2Na+1OH-1 → Pb+2(OH)-12 ↓ + 2Na+1NO3-1 (aq)

Lead II Nitrate Sodium Hydroxide Lead II Hydroxide Sodium Nitrate

Pb+2 (aq) + OH-1 (aq) → Pb(OH)2 (s) 2Na+1 (aq), 2NO3-1 (aq)

42. Pb+2(NO3)-12 (aq) + 2Na+1Cl-1 (aq) → Pb+2Cl-12 ↓ + 2Na+1NO3-1 (aq)

Lead II Nitrate Sodium Chloride Lead II Chloride Sodium Nitrate

Pb+2 (aq) + Cl-1 (aq) → PbCl2 (s) 2Na+1 (aq), 2NO3-1 (aq)

43. 2KNO3 (aq) + Zn(C2H3O2)2 (aq) → aqueous

44. KNO3 (aq) + NaI (aq) → aqueous

45. 2KNO3 (aq) + Na2CO3 (aq) → aqueous

46. 3KNO3 (aq) + Na3PO4 (aq) → aqueous

47. 2KNO3 (aq) + Na2SO4 (aq) → aqueous

48. KNO3 (aq) + NaOH (aq) → aqueous

49. KNO3 (aq) + NaCl (aq) → aqueous

**Conclusions and Questions**

1. Complete the table called “Solubility Rules for the Solubility of Salts in Water” shown on your Calculations and Data sheet.

Solubility Rules for the Solubility of Salts in Water

|  |  |  |
| --- | --- | --- |
| **Ion** | **Soluble or Insoluble?** | **Exceptions** |
| -NO3-1 | Soluble | None |
| -C2H3O2-1 | Soluble | Ag+1 Fe+3 |
| -CO3-2 | Insoluble | Na+1 K+1 |
| -PO4-3 | Insoluble | Na+1 K+1 Ba+1 Co+2 |
| -SO4-2 | Soluble | Ba+2 Pb+2 |
| -OH-1 | Insoluble | Na+1, K+1, and Ba+2 |
| -I-1 | Soluble | Pb+2 and Ag+1 |
| -Cl-1 | Soluble | Pb+2 and Ag+1 |
| -Na+1 | Soluble | None |
| -K+1 | Soluble | None |