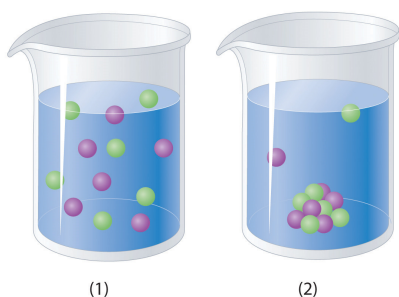## 4.6 - 4.7 Reactions in Solution
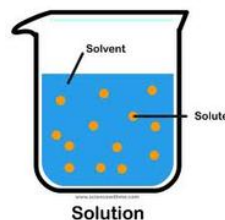

(1)   (2)

Sep 21-6:56 AM

Reactions in Aqueous Solutions

Double replacement (displacement) reactions occur between substances in aqueous solutions producing solids (called <u>precipitates</u>), water, or gases.

Aqueous solutions contain one or more <u>solutes</u> (substance that is dissolved) with water acting as a <u>solvent</u> (substance that dissolves something else).

Feb 4-1:49 PM

Ionic Equations

<u>Ionic equations</u> show details of reactions.

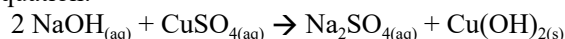<u>Complete Ionic Equation</u>: All ions in solution shown.

<u>Spectator Ions</u>: Ions that don't react are removed.

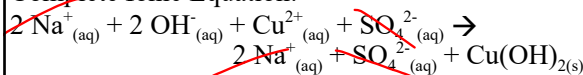<u>Net Ionic Equation</u>: Only reacting ions are shown.

Oct 10-8:45 PM

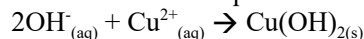## 1. Reactions that Form Precipitates

Equation:
$$2\ NaOH_{(aq)} + CuSO_{4(aq)} \rightarrow Na_2SO_{4(aq)} + Cu(OH)_{2(s)}$$

Complete Ionic Equation:
$$2\ Na^+_{(aq)} + 2\ OH^-_{(aq)} + Cu^{2+}_{(aq)} + SO_4^{\ 2-}_{(aq)} \rightarrow$$
$$2\ Na^+_{(aq)} + SO_4^{\ 2-}_{(aq)} + Cu(OH)_{2(s)}$$

Identify and remove spectator ions,

then write the Net Ionic Equation:
$$2OH^-_{(aq)} + Cu^{2+}_{(aq)} \rightarrow Cu(OH)_{2(s)}$$
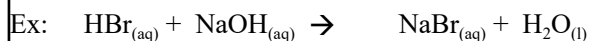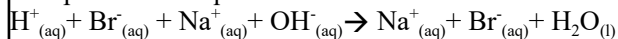

Oct 10-8:45 PM

2. Reactions that Form Water

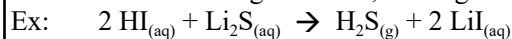Acids and bases react to form <u>water</u>. No evidence is visible: water is colorless!

Ex: $HBr_{(aq)} + NaOH_{(aq)} \rightarrow \qquad NaBr_{(aq)} + H_2O_{(l)}$

Complete Ionic Equation:
$$H^+_{(aq)} + Br^-_{(aq)} + Na^+_{(aq)} + OH^-_{(aq)} \rightarrow Na^+_{(aq)} + Br^-_{(aq)} + H_2O_{(l)}$$

Remove spectators and write the Net Equation:
$$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$$
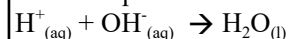
Oct 10-8:45 PM

3. Reactions that form Gases

Gases can form during reactions, making bubbles.
Ex: $2\ HI_{(aq)} + Li_2S_{(aq)} \rightarrow H_2S_{(g)} + 2\ LiI_{(aq)}$

Complete Ionic Equation:
$$2H^+_{(aq)} + 2I^-_{(aq)} + 2Li^+_{(aq)} + S^{2-}_{(aq)} \rightarrow H_2S_{(g)} + 2Li^+_{(aq)} + 2I^-_{(aq)}$$
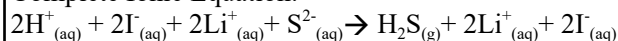
Remove the spectators and rewrite the Net Ionic Equation:
$$2H^+_{(aq)} + S^{2-}_{(aq)} \rightarrow H_2S_{(g)}$$
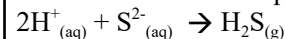
Oct 10-8:45 PM

Solving Stoichiometry Problems for Reactions in Solution

1. Identify the species present in the combined solution, and determine what reaction occurs.

2. Write the balanced net ionic equation for the reaction.

3. Calculate the moles of reactants.

4. Determine which reactant is limiting.

5. Calculate the moles of product(s), as required.

6. Convert to grams or other units, as required.

Sep 17-12:44 AM
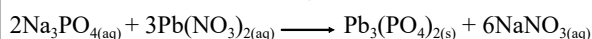
Solution Stoichiometry

10.0 mL of a 0.30 M sodium phosphate solution reacts with 20.0 mL of a 0.20 M lead(II) nitrate solution (assume no volume change) and forms a precipitate.

4. What compound will precipitate?
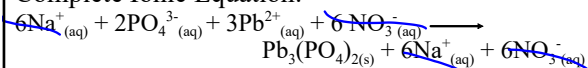
5. What mass of precipitate forms?

Sep 17-12:44 AM
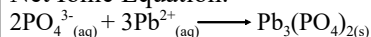
4. What compound will precipitate?

We need a balanced chemical reaction with states of matter to answer this, and guide us later:

$2Na_3PO_{4(aq)} + 3Pb(NO_3)_{2(aq)} \longrightarrow Pb_3(PO_4)_{2(s)} + 6NaNO_{3(aq)}$

Complete Ionic Equation:
$6Na^+_{(aq)} + 2PO_4^{3-}_{(aq)} + 3Pb^{2+}_{(aq)} + 6NO_3^-_{(aq)} \longrightarrow$
$\qquad Pb_3(PO_4)_{2(s)} + 6Na^+_{(aq)} + 6NO_3^-_{(aq)}$

Net Ionic Equation:
$2PO_4^{3-}_{(aq)} + 3Pb^{2+}_{(aq)} \longrightarrow Pb_3(PO_4)_{2(s)}$

Sep 17-1:00 AM

5. What mass of precipitate forms?

We must figure out limiting reactant.
Determine moles of reactants:

$$0.0100\,L\,Na_3PO_4 \cdot \frac{0.30\,mol\,Na_3PO_4}{1L\,Na_3PO_4} = 0.0030\,mol\,Na_3PO_4$$

$$0.0200\,L\,Pb(NO_3)_2 \cdot \frac{0.20\,mol\,Pb(NO_3)_2}{1L\,Pb(NO_3)_2} = 0.0040\,mol\,Pb(NO_3)_2$$

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5. What mass of precipitate forms?

Given Ratio:
$$\frac{0.0030\,mol\,Na_3PO_4}{0.0040\,mol\,Pb(NO_3)_2} = \frac{0.75\,mol\,Na_3PO_4}{1\,mol\,Pb(NO_3)_2}$$

From Balanced Reaction:
$$\frac{2\,mol\,Na_3PO_4}{3\,mol\,Pb(NO_3)_2} = \frac{0.66\,mol\,Na_3PO_4}{1\,mol\,Pb(NO_3)_2}$$

Which runs out first???
Lead (II) nitrate is limiting.

Sep 17-1:00 AM

5. What mass of precipitate forms?

Using stoichiometry, starting with the limiting reactant:

$$0.0040\,mol\,Pb(NO_3)_2 \cdot \frac{1\,mol\,Pb_3(PO_4)_2}{3\,mol\,Pb(NO_3)_2} \cdot \frac{811.54\,g\,Pb_3(PO_4)_2}{1\,mol\,Pb_3(PO_4)_2}$$

$$= \boxed{1.1\,g\,Pb_3(PO_4)_2}$$

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6. What is the concentration of nitrate ions left in solution after the reaction is complete?

Lead (II) nitrate produces TWO nitrate ions are in each formula unit (see complete ionic equation).

$$0.004\, mol\, Pb(NO_3)_2 \cdot \frac{2\, mol\, NO_3^-}{1\, mol\, Pb(NO_3)_2} = 0.0080\, mol\, NO_3^-$$

Using the definition of molarity:

$$M = \frac{mol}{L} = \frac{0.0080\, mol\, NO_3^-}{0.030\, L\, solution} = \boxed{0.27\, M\, NO_3^-}$$

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Homework

Read 4.8 in your Textbook

4.6 - 4.7 Problems in your Booklet
Due: Next Class.

Sep 21-7:50 AM