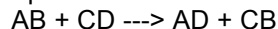


Objective 5. Double replacement reactions 1: balancing precipitation reactions, applying solubility table, write net ionic equations to predict whether a reaction occurs, perform mole-mass and mole ratio calculations (gravimetric)

Quiz Practice problems:

Key ideas: In a double replacement reaction, an ionic compound reacts with another ionic compound to form two new ionic compounds. The ions in the reactant ionic compounds replace or exchange with each other.



One type of double replacement reaction is a precipitation reaction.

A net ionic equation is used to predict whether a reaction occurs.

Skills: Given reactants of a double replacement reaction, predict the products (write chemical formulas) of the reaction.

Balance a double replacement reaction.

Use Table of solubility rules of ionic compounds.

Identify the precipitate in a double replacement reaction.

Write a net ionic equation. Identify spectator ions.

Predict whether a reaction occurs from a net ionic equation.

Perform chemical calculations involving a double replacement reaction.

1. Determine if the compound is soluble in water. If so, what ions form when the compound dissolves in water?

Example: NaCl is soluble in water (see rule for sodium compounds or halide compounds).

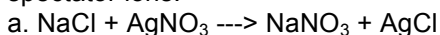
NaCl forms Na^+ ion and Cl^- ion.

- sodium phosphate
- CaCO_3
- KOH
- AgCl
- NH_4NO_3
- barium sulfate

2. Two ions are in solution. Will these two ions combine to form a precipitate?

- calcium and chloride
- Na^+ and SO_4^{2-}
- potassium and carbonate
- Mg^{2+} and NO_3^-
- Mg^{2+} and carbonate

3. The following precipitation reactions occur. Which product is the precipitate? Write a net ionic equation. Identify the spectator ions.

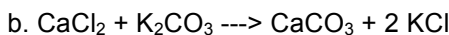


Precipitate = AgCl (see Table of solubility of ionic compounds)

Ionic equation: $\text{Na}^+ + \text{Cl}^- + \text{Ag}^+ + \text{NO}_3^- \rightarrow \text{Na}^+ + \text{NO}_3^- + \text{AgCl}(\text{s})$

Net ionic equation: $\text{Cl}^- + \text{Ag}^+ \rightarrow \text{AgCl}(\text{s})$

Spectator ions: $\text{Na}^+ + \text{NO}_3^-$

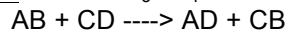


c. barium chloride + sodium sulfate \rightarrow

You can predict whether a precipitation reaction occurs if you can write a net ionic equation.

4. Predict whether the reaction occurs. If so, write a net ionic equation.

Example: $\text{KCl} + \text{Na}_3\text{PO}_4 \rightarrow$



Products: $\text{KCl} + \text{Na}_3\text{PO}_4 \rightarrow \text{K}_3\text{PO}_4 + \text{NaCl}$

Balance the equation: $3 \text{KCl} + \text{Na}_3\text{PO}_4 \rightarrow \text{K}_3\text{PO}_4 + 3 \text{NaCl}$

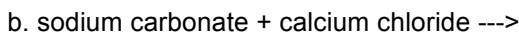
See Table of solubility of ionic compounds: KCl, Na_3PO_4 , K_3PO_4 , and NaCl are soluble.

Ionic equation: $3 \text{K}^+ + 3 \text{Cl}^- + 3 \text{Na}^+ + \text{PO}_4^{3-} \rightarrow 3 \text{K}^+ + \text{PO}_4^{3-} + 3 \text{Na}^+ + 3 \text{Cl}^-$

Every ion cancels out so each ion is a spectator ion. Therefore, this reaction does not occur.



(Answer: this reaction occurs so you should be able to write a net ionic equation. One product is solid $\text{Mg}(\text{OH})_2$.)



(Answer: this reaction occurs.)

In many reactions, all of one reactant reacts (this reactant is called the **limiting** reactant) and not all of other reactant reactants (this reactant is called the **excess** reactant).

c. 10 g of CaCl_2 is mixed with 10 g of K_2CO_3 . A reaction occurs (see Question 3b). The limiting reactant is K_2CO_3 . Calculate the moles of excess CaCl_2 leftover.

(Answer: original moles of CaCl_2 = 0.090 moles, moles of CaCl_2 that reacts with 10 g of K_2CO_3 = 0.072 moles, moles of CaCl_2 leftover = 0.018 moles)

d. 50 g of CaCl_2 is mixed with 200 g of AgNO_3 . A reaction occurs. All of the CaCl_2 reacts.



(i) You have 50 g of CaCl_2 . Moles of CaCl_2 = _____.

If **all** of the CaCl_2 reacts, how many moles of AgNO_3 reacts with it? (What is the conversion factor?)

(ii) You have 200 g of AgNO_3 . Moles of AgNO_3 = _____.

If **all** of the AgNO_3 reacts, how many moles of CaCl_2 reacts with it?

(iii) The limiting reactant is _____. (Compare your answers to (i) and (ii).)

(iv) The mass of AgNO_3 that is leftover (excess) = _____ g. (Answer: between 45 and 50 g)

e. The amount of salt in water is determined by testing for chloride ion. Silver nitrate solution is added to the salt-containing water sample. The precipitate that forms is collected, dried, and weighed. The mass of chloride ion and salt is calculated from the mass of precipitate.

(i) Write a molecular equation and net ionic equation that represents this reaction. What is the precipitate that forms?

(ii) 10.0 ml of a saline sample is analyzed. Silver nitrate solution is added. How can you make sure that all of the chloride precipitates out of solution? In other words, which reactant should be the limiting reactant? Give reasons.

(iii) You want the % yield of this reaction to be 100%. Explain why.

(iv) 0.25 g of precipitate is collected, dried, and weighed. What is the chemical formula of the precipitate? Calculate the mass of sodium ion. (Answer: approximately 0.04 g Na^+ in 10.0 ml of water)

(v) The RDA of sodium is 2300 mg per day. Would you drink a cup (240 ml) of this water to get your RDA of sodium?

(vi) 100 g of NaCl is dissolved in water. This solution is mixed with 100 g of silver nitrate dissolved in water. Which reactant is the limiting reactant?

Calculate the mass of AgCl that precipitates out of solution. (Answer: between 80 and 90 g)

5. The quality of drinking water depends on the impurities and their concentrations in a water sample. Drinking water that contains sulfate in excess of 500 mg SO_4^{2-} /liter may cause laxative effects. You are given 25.00 ml of a water sample. 32.95 ml of 0.257 M barium chloride solution is added to this 25.00 ml water sample. 1.26 g of barium sulfate is collected, dried, and weighed.

a. Describe how to prepare 250 ml of 0.25 M barium chloride solution from solid barium chloride.

b. Write a molecular equation and net ionic equation that represents the reaction that occurs.

c. Calculate the moles of barium chloride. (Hint: Molarity = moles/volume. Solve for moles.)

d. Which reactant should be the limiting reactant?

e. Calculate the mass of sulfate in mg SO_4^{2-} /liter in this water sample.

f. Would you drink this water? Give reasons.

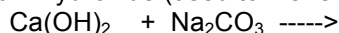
6. Predict whether each reaction occurs. (Hint: write a net ionic equation.)

a. Na_2SO_4 (aq) + $\text{Ba}(\text{NO}_3)_2$ (aq) \rightarrow

b. Saline solution (NaCl (aq)) is added to KNO_3 (aq).

c. You mix baking soda with lye (NaOH).

7. Sodium hydroxide (used to make paper, Al, textiles, soaps) is produced in industry by the following reaction:



How much of each reactant is needed to make 1 ton of sodium hydroxide?