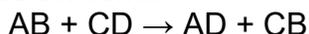




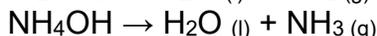
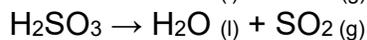
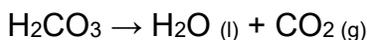
Double Replacement Reactions

A double replacement reaction has the form:



There are four different possible outcomes to a reaction such as this:

[1] **Formation of a gas.** There are certain compounds which are unstable and decompose to water and a gas. Three common ones are H_2CO_3 , H_2SO_3 and NH_4OH . They decompose like this:



When any of these three compounds appears as a product, write the decomposed form instead.

[2] **Formation of a slightly ionized compound.** Look for compounds like H_2O , $\text{HC}_2\text{H}_3\text{O}_2$ (acetic acid), $\text{H}_2\text{C}_2\text{O}_4$ (oxalic acid) or H_3PO_4 as products. Heat release is the evidence of the formation of these compounds. Any of these compounds should be marked as "(l)".

[3] **Formation of a precipitate.** Consult the solubility table on page 61–62 in the Chem 061/071 Lab Manual or the User-Friendly Solubility Table from the Learning Centre. "Low solubility" means that very little of the substance dissolves in water, so most of it forms as a precipitate, and should be marked "(s)". "Soluble" means that the ions will stay in solution.

[4] **There is no reaction.** None of the above happens, probably because the ions all stay in solution.

Example 1: Complete and balance the following equation, if a reaction occurs:
 $\text{Na}_2\text{CO}_3 (\text{aq}) + \text{HCl} (\text{aq}) \rightarrow ?$

Solution: [1] **Determine what ions are formed.** Consult a list of ions if necessary. The ions in this case are Na^+ (not Na_2^+), CO_3^{2-} , H^+ , and Cl^- .

[2] **Form the hypothetical products.** Take into account the valences of the ions involved. The products here would be NaCl and H_2CO_3 .

[3] **Look for precipitates, slightly ionized compounds and unstable compounds on the product side.** We want to make sure that a reaction will actually occur before we do too much work! In this case, NaCl is soluble and so is H_2CO_3 , but H_2CO_3 is unstable, so there will be a reaction.

[4] **Write the double replacement equation, if there is a reaction.**



The equation is $\text{Na}_2\text{CO}_3 \text{ (aq)} + \text{HCl} \text{ (aq)} \rightarrow \text{NaCl} + \text{H}_2\text{CO}_3$.

[5] Balance the equation, then adjust it for unstable compounds and gases. It's easier to do it this way than to break down the gases and balance it afterwards.

$\text{Na}_2\text{CO}_3 + 2 \text{HCl} \rightarrow 2 \text{NaCl} + \text{H}_2\text{CO}_3$ which becomes:

$\text{Na}_2\text{CO}_3 + 2 \text{HCl} \rightarrow 2 \text{NaCl} \text{ (aq)} + \text{H}_2\text{O} \text{ (l)} + \text{CO}_2 \text{ (g)}$

Example 2: Complete and balance the following equation, if a reaction occurs:
 $\text{NaOH} + \text{HCl} \rightarrow ?$

Solution: We'll use the same steps as in Example 1.

[1] Determine what ions are formed.

Na^+ , OH^- , H^+ , Cl^- .

[2] Form the hypothetical products.

NaCl and H_2O .

[3] Look for precipitates, slightly ionized compounds and unstable compounds on the product side.

NaCl is soluble. H_2O is a slightly ionized compound, so a reaction will occur.

[4] Write the double replacement equation, if there is a reaction.

$\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} \text{ (aq)} + \text{H}_2\text{O} \text{ (l)}$

[5] Balance the equation, then adjust it for unstable compounds and gases.

It's balanced as it stands, so we're done.

Example 3: Complete and balance the following equation, if a reaction occurs:
 $\text{NaCl} + \text{AgNO}_3 \rightarrow ?$

Solution: **[1] Determine what ions are formed.**

Na^+ , Cl^- , Ag^+ , NO_3^- .

[2] Form the hypothetical products.

NaNO_3 and AgCl .

[3] Look for precipitates, slightly ionized compounds and unstable compounds on the product side.

NaNO_3 is soluble, but AgCl has low solubility, so a reaction will occur.

[4] Write the double replacement equation, if there is a reaction.

$\text{NaCl} + \text{AgNO}_3 \rightarrow \text{NaNO}_3 \text{ (aq)} + \text{AgCl} \text{ (s)}$

[5] Balance the equation, then adjust it for unstable compounds and gases.

It's balanced as it stands, so we're done.



Example 4: Complete and balance the following equation, if a reaction occurs:
 $\text{NaCl} + \text{KNO}_3 \rightarrow ?$

Solution: [1] **Determine what ions are formed.**
 $\text{Na}^+, \text{Cl}^-, \text{K}^+, \text{NO}_3^-$.

[2] **Form the hypothetical products.**
 NaNO_3 and KCl .

[3] **Look for precipitates, slightly ionized compounds and unstable compounds on the product side.**

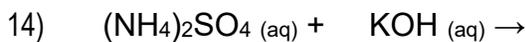
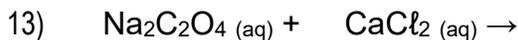
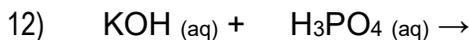
NaNO_3 and KCl are both soluble, so no reaction will occur. We can stop at this step, since these ions will stay in solution.

EXERCISES

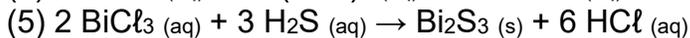
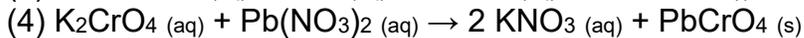
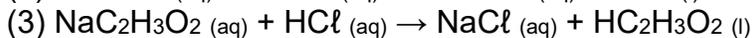
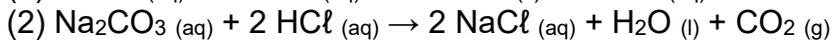
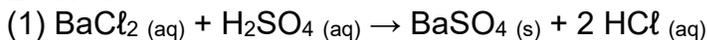
Complete and balance the following equations, if a reaction occurs:

- 1) $\text{BaCl}_2 (\text{aq}) + \text{H}_2\text{SO}_4 (\text{aq}) \rightarrow$
- 2) $\text{Na}_2\text{CO}_3 (\text{aq}) + \text{HCl} (\text{aq}) \rightarrow$
- 3) $\text{NaC}_2\text{H}_3\text{O}_2 (\text{aq}) + \text{HCl} (\text{aq}) \rightarrow$
- 4) $\text{K}_2\text{CrO}_4 (\text{aq}) + \text{Pb}(\text{NO}_3)_2 (\text{aq}) \rightarrow$
- 5) $\text{BiCl}_3 (\text{aq}) + \text{H}_2\text{S} (\text{aq}) \rightarrow$
- 6) $\text{SrS} (\text{aq}) + \text{FrClO}_3 (\text{aq}) \rightarrow$
- 7) $\text{K}_2\text{C}_2\text{O}_4 (\text{aq}) + \text{HCl} (\text{aq}) \rightarrow$
- 8) $\text{H}_3\text{PO}_4 (\text{aq}) + \text{Ca}(\text{OH})_2 (\text{aq}) \rightarrow$
- 9) $(\text{NH}_4)_2\text{CO}_3 (\text{aq}) + \text{HNO}_3 (\text{aq}) \rightarrow$

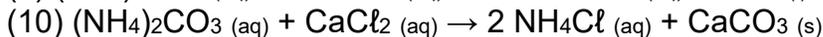
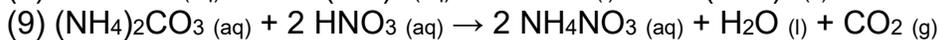
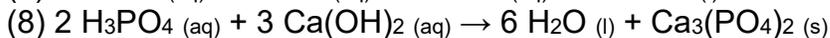
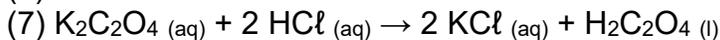




SOLUTIONS



(6) no reaction



(11) no reaction

