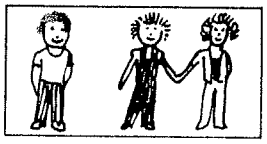
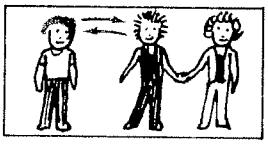
AIM 16 | What is a replacement reaction?

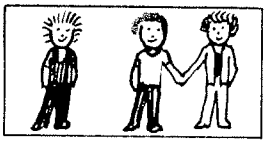
Imagine that three children are playing.



Two are holding hands. The other is alone.



The child that was alone now joins the others. He takes the place of one of the children.



Now a different child is alone.

We have the same children that we started with. But, now they are arranged in a different way.

Some chemical reactions work like this. A free element takes the place of or replaces another element of a compound.

The element that was replaced is now "free."

$$\underset{\text{free element}}{A} + \underset{\text{compound}}{BC} \longrightarrow \underset{\text{new compound}}{AC} + \underset{\text{new free element}}{B}$$

Let's study an actual replacement reaction—one between zinc (Zn) and hydrochloric acid (HCl).

The zinc is the "free" element. The hydrochloric acid is in the compound.

$$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$$

The zinc replaces the hydrogen. The hydrogen is set free.

The reaction produces a new compound, zinc chloride ($ZnCl_2$), and free hydrogen (H_2). Notice that the elements we started with are the elements we ended with. They are just arranged in a different way.

This kind of reaction is called a *single replacement reaction*. In a single replacement reaction, a free element replaces a different element of a compound.

UNDERSTANDING SINGLE REPLACEMENT REACTIONS

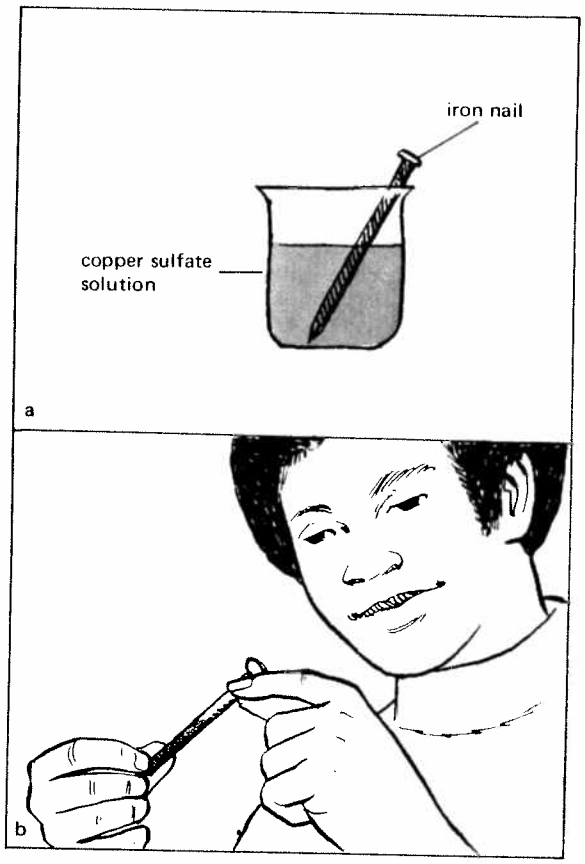


Figure A

What You Need

iron nail
copper sulfate solution
beaker

How To Do The Experiment

Place an iron nail in copper sulfate solution.

Remove the nail in a few minutes.

What You Saw

The nail is coated with copper.

This is the equation for the reaction.

$$Fe + CuSO_4 \longrightarrow FeSO_4 + Cu$$

Iron — Copper sulfate — Iron sulfate — Copper

Answer these questions.

1. Name the *free element* we started with. _____
2. Name the *compound* we started with. _____
3. Name the *free element* we ended with. _____
4. Name the *compound* we ended with. _____
5. **a)** Which element did the iron replace? _____
   b) What happened to this element? _____
6. What do we call this kind of chemical reaction? _____
7. What happens during a single replacement reaction? _____

_____

IDENTIFYING SINGLE REPLACEMENT REACTIONS

Six equations are listed below. Some are single replacement reactions. Some are not. Mark a check (√) in the correct box next to each equation.

	Equation	Single replacement reaction	Not a single replacement reaction
1.	$C + 2S \longrightarrow CS_2$		
2.	$H_2O_2 \longrightarrow H_2 + O_2$		
3.	$2Al + 6HCl \longrightarrow 2AlCl_3 + 3H_2$		
4.	$2K + Cl_2 \longrightarrow 2KCl$		
5.	$Zn + PbO \longrightarrow ZnO + Pb$		
6.	$Fe + CuSO_4 \longrightarrow FeSO_4 + Cu$		

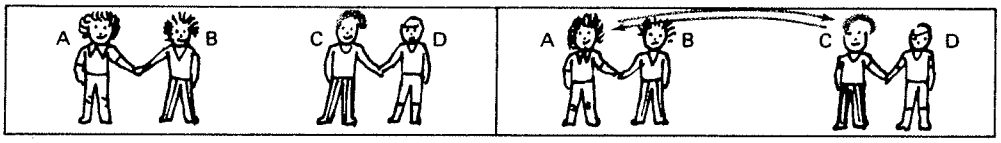
DOUBLE REPLACEMENT REACTIONS

A *single* replacement reaction takes place between an element and a compound. The free element replaces one of the elements of the compound. This produces a new compound and a new free element.

$$\underset{\text{free element}}{A} + \underset{\text{compound}}{BC} \longrightarrow \underset{\text{new compound}}{AC} + \underset{\text{new free element}}{B}$$

A *double* replacement reaction takes place between two *compounds*. A part of one compound changes place with a part of the other compound.

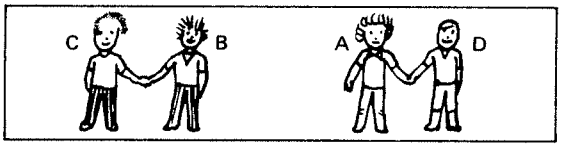
Let's use playing children as models again to see what happens.



Children A and B stand for compound AB.

Children C and D stand for compound CD.

Child A changes place with child C.



What do we have now? Instead of compound AB + CD, we have two *new* compounds—CB and AD.

When there are two changeovers, *a double* replacement has taken place.

Now let's study an *actual* double replacement reaction—the reaction between sodium hydroxide (NaOH), and hydrochloric acid (HCl).

$$NaOH + HCl \longrightarrow NaCl + HOH^*$$

- The sodium and hydrogen change places.
- Two new *compounds* form—NaCl (common table salt) and HOH (water).

Now you try. Read each equation carefully. Then answer the questions or fill in the blanks with each.

Equation I.

$$BaCl_2 + Na_2SO_4 \longrightarrow BaSO_4 + 2NaCl$$

Barium chloride — Sodium sulfate — Barium sulfate — Sodium chloride

1. Name the reactants. _____ _____
2. The reactants are _____ (all elements, all compounds, an element and a compound).
3. The barium changed places with the _____ (sulfate, chlorine, sodium).
4. Name the products. _____ _____
5. The products are _____ (all elements, all compounds, an element and a compound).
6. What kind of chemical reaction is this? _____
7. Double replacement is the reaction of two _____ to form two new _____.

Equation II.

$$AgNO_3 + NaBr \longrightarrow AgBr + NaNO_3$$

Silver nitrate — Sodium bromide — Silver bromide — Sodium nitrate

8. Name the reactants. _____ _____
9. The reactants are _____ (all elements, all compounds, an element and a compound).
10. The silver changed places with the _____ (sodium, bromine, nitrate).
11. Name the products. _____ _____
12. The products are _____ (all elements, all compounds, an element and a compound).
13. What kind of chemical reaction is this? _____

*The formula for water may be written HOH as well as H_2O.

IDENTIFYING DOUBLE REPLACEMENT REACTIONS

Eight equations are listed below. Some are double replacement reactions. Some are not. Mark a check (√) in the correct box next to each equation.

	Equation	Double replacement reaction	*Not* a double replacement reaction
1.	$Mg(OH_2) + 2HCl \longrightarrow MgCl_2 + 2HOH$		
2.	$C_6H_{10}O_5 + H_2O \longrightarrow C_6H_{12}O_6$		
3.	$Na_2SO_4 + BaCl_2 \longrightarrow 2NaCl + BaSO_4$		
4.	$3Mg + N_2 \longrightarrow Mg_3N_2$		
5.	$H_2SO_4 + BaCl_2 \longrightarrow 2HCl + BaSO_4$		
6.	$ZnCO_3 \longrightarrow ZnO + CO_2$		
7.	$CuSO_4 + H_2S \longrightarrow H_2SO_4 + CuS$		
8.	$NH_4NO_3 \longrightarrow 2H_2O + N_2O$		

IDENTIFYING CHEMICAL REACTIONS

Ten chemical equations are listed below. Identify each kind of reaction: *synthesis, decomposition, single replacement,* or *double replacement.*

	Equation	Kind of reaction
1.	$N_2 + 3H_2 \longrightarrow 2NH_3$	
2.	$2Br_2 + 2H_2O \longrightarrow 4HBr + O_2$	
3.	$Mg + 2HCl \longrightarrow MgCl_2 + H_2$	
4.	$2KBr + H_2SO_4 \longrightarrow K_2SO_4 + 2HBr$	
5.	$H_2SO_3 \longrightarrow H_2O + SO_2$	
6.	$Na_2S + 2HCl \longrightarrow 2NaCl + H_2S$	
7.	$2Na + I_2 \longrightarrow 2NaI$	
8.	$NaCl + AgNO_3 \longrightarrow NaNO_3 + AgCl$	
9.	$H_2 + Cl_2 \longrightarrow 2HCl$	
10.	$H_2CO_3 \longrightarrow H_2O + CO_2$	