

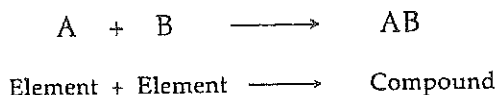
LESSON | What is a synthesis

14 | reaction?

Chemical reactions are happening around you all the time. A match burns. A car rusts. Food spoils. Leaves decay. These are just a few chemical reactions.

Probably the most important chemical reactions take place in your body. They are happening this very moment. Digestion is a chemical process. So is respiration. In every one of your trillions of cells, chemical reactions are taking place all the time. Life depends upon chemical reactions.

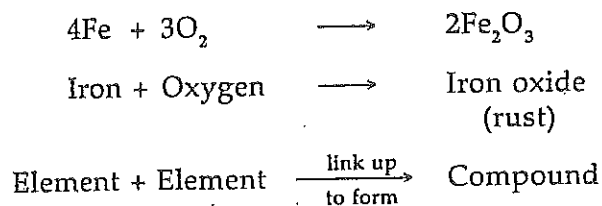
There are several kinds of chemical reactions. One kind is the synthesis [SIN-thuh-sis] reaction. "Synthesis" means a putting together. A synthesis reaction combines substances, usually elements, to form a compound. When the compound forms, we say it has been synthesized. Below is a "model" of a synthesis reaction.



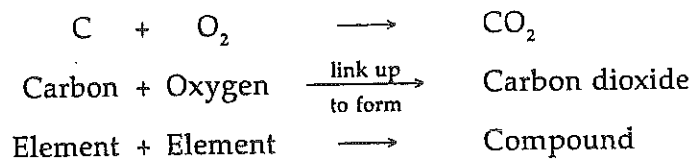
Let's study two synthesis reactions.

RUSTING When iron rusts, it combines with oxygen.

Remember this equation?



THE BURNING OF CARBON Charcoal is made of the element carbon (C). When carbon burns, it combines with oxygen. This produces the gas carbon dioxide (CO₂).



A synthesis reaction is like any other kind of chemical reaction. No matter is created. No matter is destroyed. The atoms just change their arrangement.

UNDERSTANDING SYNTHESIS REACTIONS

Look at Figures A through E and read the explanation. Then answer the questions with each.

When hydrogen explodes, it combines with oxygen. Water is produced. This equation shows what happens:

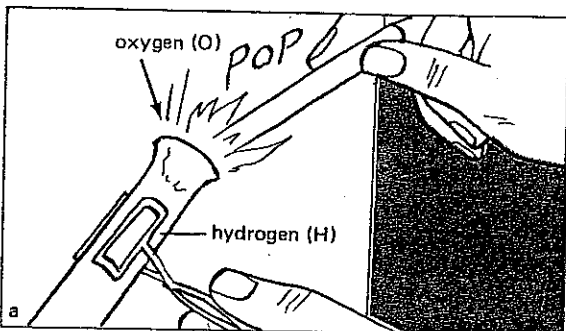
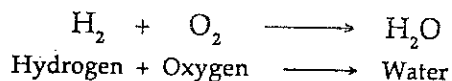


Figure A

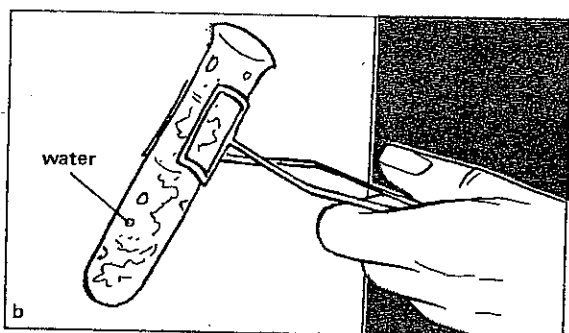


Figure B

When powdered sulfur and iron filings are heated together, they form iron sulfide.

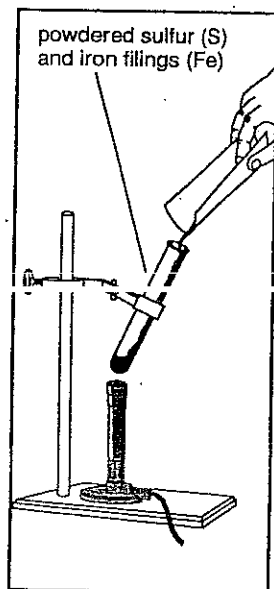


Figure C

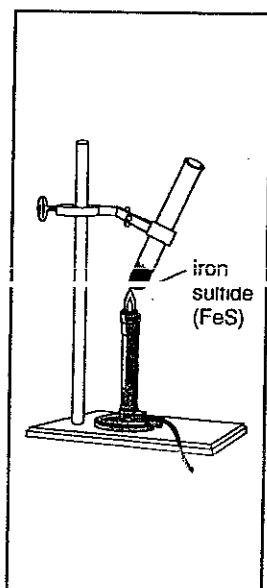
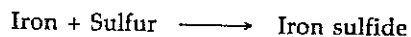
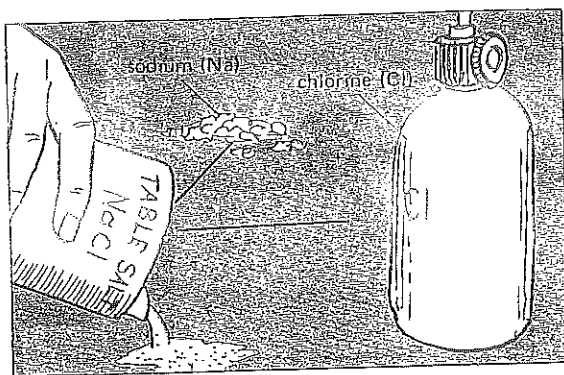


Figure D

This equation shows what happens:



1. Iron is _____
an element, a compound
2. Sulfur is _____
an element, a compound
3. Iron sulfide is _____
an element, a compound
4. What happens to the iron and sulfur when they form iron sulfide? _____



Sodium combines with chlorine to form sodium chloride—common table salt.

This equation shows what happens:

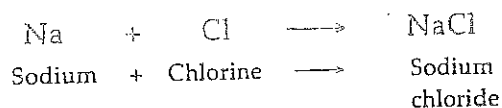


Figure E

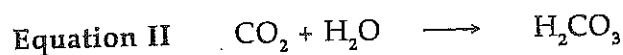
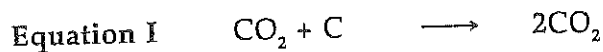
- Sodium is _____
an element, a compound
- Chlorine is _____
an element, a compound
- Sodium chloride is _____
an element, a compound
- What kind of reaction is the formation of sodium chloride? _____
Why? _____

YOUR OWN WORDS, PLEASE

- What does "synthesis" mean? _____

- What does "synthesis reaction" mean? _____

Two synthesis equations are shown below. They are different from the ones you have already seen.



- How is Equation I different from the other synthesis equations in this lesson?

- How is Equation II different from the other synthesis equations in this lesson?

IDENTIFYING SYNTHESIS REACTIONS

Ten equations are listed below. Some are synthesis reactions. Some are not. Make a check (✓) in the correct box next to each equation.

| | Equation | A Synthesis Reaction | Not a Synthesis Reaction |
|-----|--|----------------------------|--------------------------------|
| 1. | $2K + Br_2 \longrightarrow 2KBr$ | | |
| 2. | $2H_2O \longrightarrow 2H_2 + O_2$ | | |
| 3. | $NaCl \longrightarrow Na + Cl$ | | |
| 4. | $4Au + 3O_2 \longrightarrow 2Au_2O_3$ | | |
| 5. | $2Na + 2HCl \longrightarrow 2NaCl + H_2$ | | |
| 6. | $Cu + Br_2 \longrightarrow CuBr_2$ | | |
| 7. | $Zn + S \longrightarrow ZnS$ | | |
| 8. | $2Na + Br_2 \longrightarrow 2NaBr$ | | |
| 9. | $2HgO \longrightarrow 2Hg + O_2$ | | |
| 10. | $2Na + I_2 \longrightarrow 2NaI$ | | |

TRUE OR FALSE

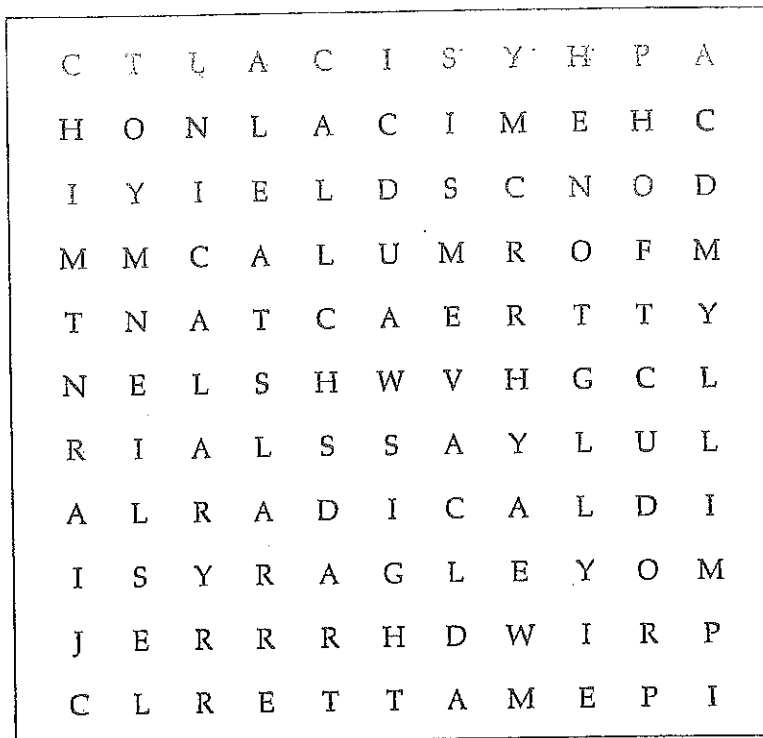
In the space provided, write "true" if the sentence is true. Write "false" if the sentence is false.

- _____ 1. There is only one kind of chemical reaction.
- _____ 2. A synthesis reaction separates a compound into its elements.
- _____ 3. The reactants of every synthesis reaction are elements.
- _____ 4. The product of a synthesis reaction is a compound.
- _____ 5. Chemical reactions take place only in the laboratory.

WORD SEARCH

The list on the left contains words that you have used in this Lesson. Find and circle each word where it appears in the box. The spellings may go in any direction: up, down, left, right, or diagonally.

MATTER
 POLYVALENT
 RADICAL
 MASS
 REACTANT
 FORMULA
 PHYSICAL
 PRODUCT
 YIELDS
 CHEMICAL



REACHING OUT

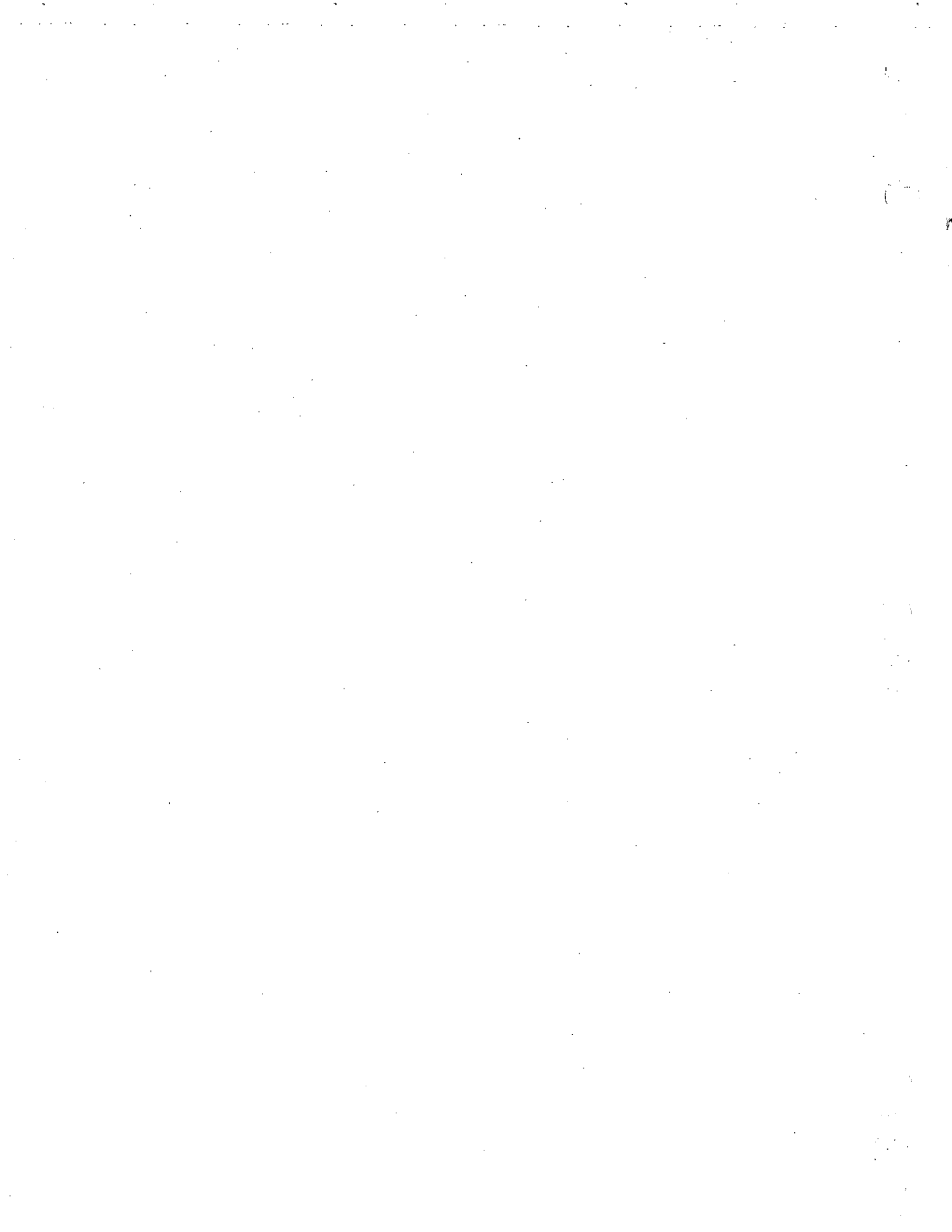
Most compounds made of only two elements have names ending in *-ide*. For example:

NaCl = sodium chloride

K₂S = potassium sulfide

Can you name these compounds?

| | Formula | Name |
|----|---------|------|
| 1. | CaO | |
| 2. | KI | |
| 3. | NaBr | |
| 4. | AgF | |
| 5. | MgCl | |



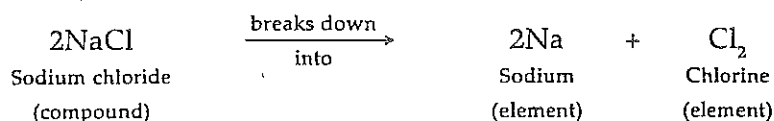
LESSON 15 | What is a decomposition reaction?

Synthesis reactions build compounds. Anything that can be built can also be taken apart. The breakdown of a compound into simpler substances is called decomposition [dee-kahn-puh-ZISH-un]. Decomposition is a chemical process.

Let us look at two examples.

1. Common table salt (sodium chloride) is a compound. It is composed of the elements sodium and chlorine.

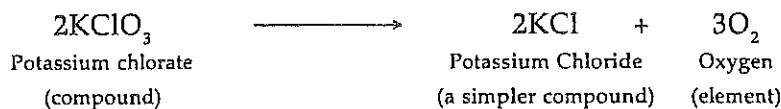
Sodium chloride can be melted. If electricity is passed through melted sodium chloride, it decomposes. The molecules unlock. They change back to atoms of sodium and chlorine. This equation shows the reaction:



The decomposition of a compound by means of electricity is called electrolysis [i-lek-TRAHL-uh-sis]. Only certain compounds can be decomposed by electrolysis. Usually these compounds are liquids.

2. Potassium chlorate (KClO_3) is a compound. It is composed of the elements potassium, chlorine, and oxygen.

Heat decomposes potassium chlorate. Potassium chlorate changes to oxygen and potassium chloride (a simpler compound). This equation shows the reaction:



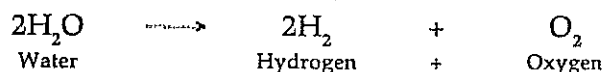
Notice that the decomposition is not complete. The oxygen has been separated. But the potassium and chlorine are still joined to form the compound potassium chloride. Another kind of decomposition reaction can separate potassium chloride into its elements.

Only certain compounds are decomposed with heat.

UNDERSTANDING DECOMPOSITION REACTIONS

Look at Figure A. Then answer the questions or fill in the blanks.

Electrolysis decomposes water. This is the equation for the reaction:



1. What is the formula for water? _____
2. Water is _____
an element, a compound
3. Name the elements that make up water.

4. Name the process that decomposes water.

5. What kind of energy is used?

6. When water decomposes. It changes to the elements _____ and _____
7. Water is in the _____ state.
solid, liquid, gas
8. Hydrogen is in the _____ state.
solid, liquid, gas
9. Oxygen is in the _____ state.
solid, liquid, gas
10. Which is simpler, water or the elements that make up water? _____

11. Decomposition _____ compounds.
builds up, breaks down
12. Can electrolysis decompose every compound? _____
13. Name another compound that can be decomposed with electrolysis.

14. A compound that can be separated by electrolysis must be in which state of matter?

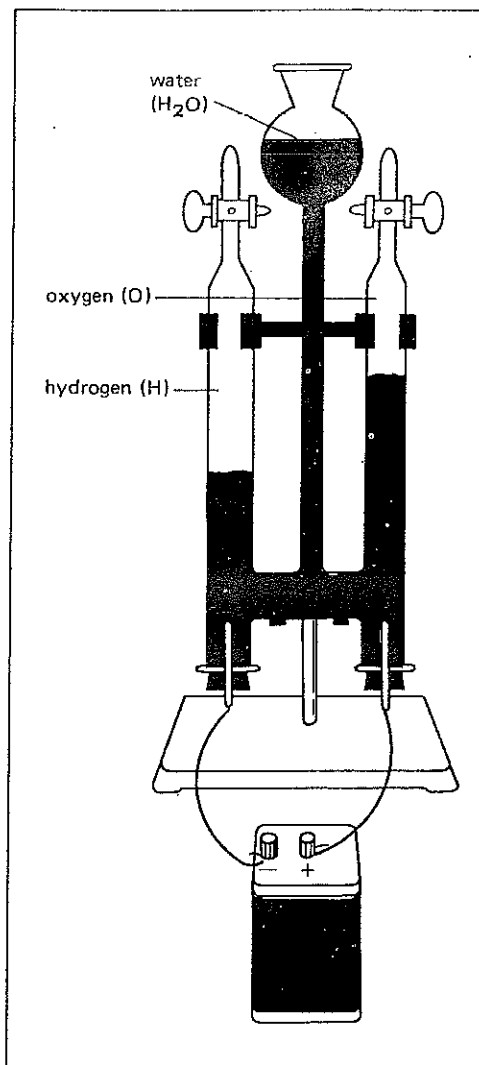


Figure A

Look at Figure B. Answer the questions.

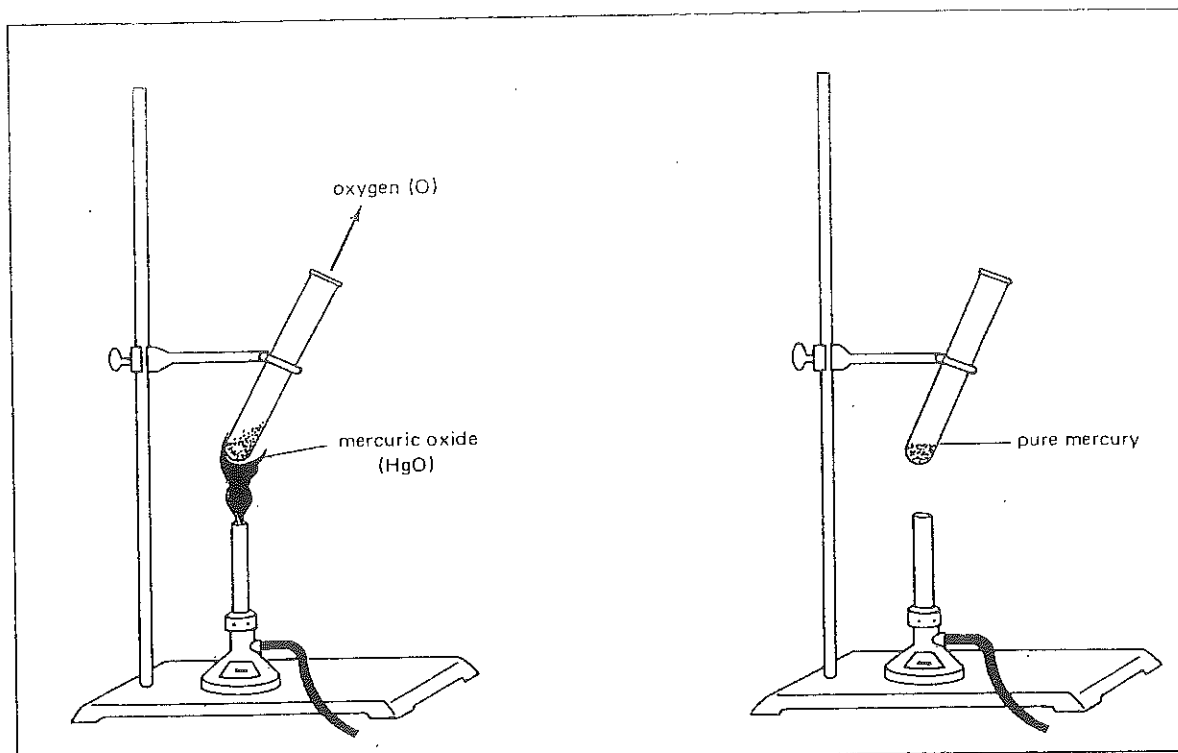
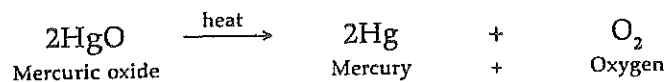


Figure B

Mercuric oxide is a solid. Heat decomposes mercuric oxide. This is the equation for the reaction.



1. What is the formula for mercuric oxide? _____
2. Mercuric oxide is _____
an element, a compound
3. Name the elements that make up mercuric oxide. _____

4. What happens when mercuric oxide is heated? _____
5. What kind of energy decomposes mercuric oxide? _____
6. When mercuric oxide decomposes, it changes to the elements _____ and _____
7. Mercuric oxide is in the _____ state.
solid, liquid, gas

8. Mercury is in the _____ state.
solid, liquid, gas

9. Oxygen is in the _____ state.
solid, liquid, gas

10. Which is simpler: mercuric oxide or the elements that make up mercuric oxide?

11. The mercury _____
stays in the test tube, escapes into the air

12. The oxygen _____
stays in the test tube, escapes into the air

13. Can heat decompose every compound? _____

14. Name another compound that can be decomposed by heat. _____

FILL IN THE BLANK

Complete each statement using a term or terms from the list below. Write your answers in the spaces provided.

heating

Potassium chlorate

liquid

simpler

mercuric oxide

synthesis

fewer

water

electrolysis

molten sodium chloride

decomposition

1. The combining of substances to form a compound is called _____.

2. The breakdown of a compound into simpler substances is called _____.

3. Two methods used to decompose compounds are _____ and _____.

4. For a compound to decompose by electrolysis, it must be in a _____ state.

5. Two compounds that can be decomposed by electrolysis are _____ and _____.

6. Two compounds that can be decomposed by heat are _____ and _____.

7. Atoms are _____ than molecules.

8. KCl is a simpler compound than KClO_3 because KCl has _____ elements and atoms.

MATCHING

Match each term in Column A with its description in Column B. Write the correct letter in the space provided.

| Column A | Column B |
|---------------------------------|-----------------------------|
| _____ 1. synthesis reaction | a) breaks down compounds |
| _____ 2. decomposition reaction | b) uses electricity |
| _____ 3. electrolysis and heat | c) methods of decomposition |
| _____ 4. electrolysis | d) simpler than a compound |
| _____ 5. an element | e) builds compounds |

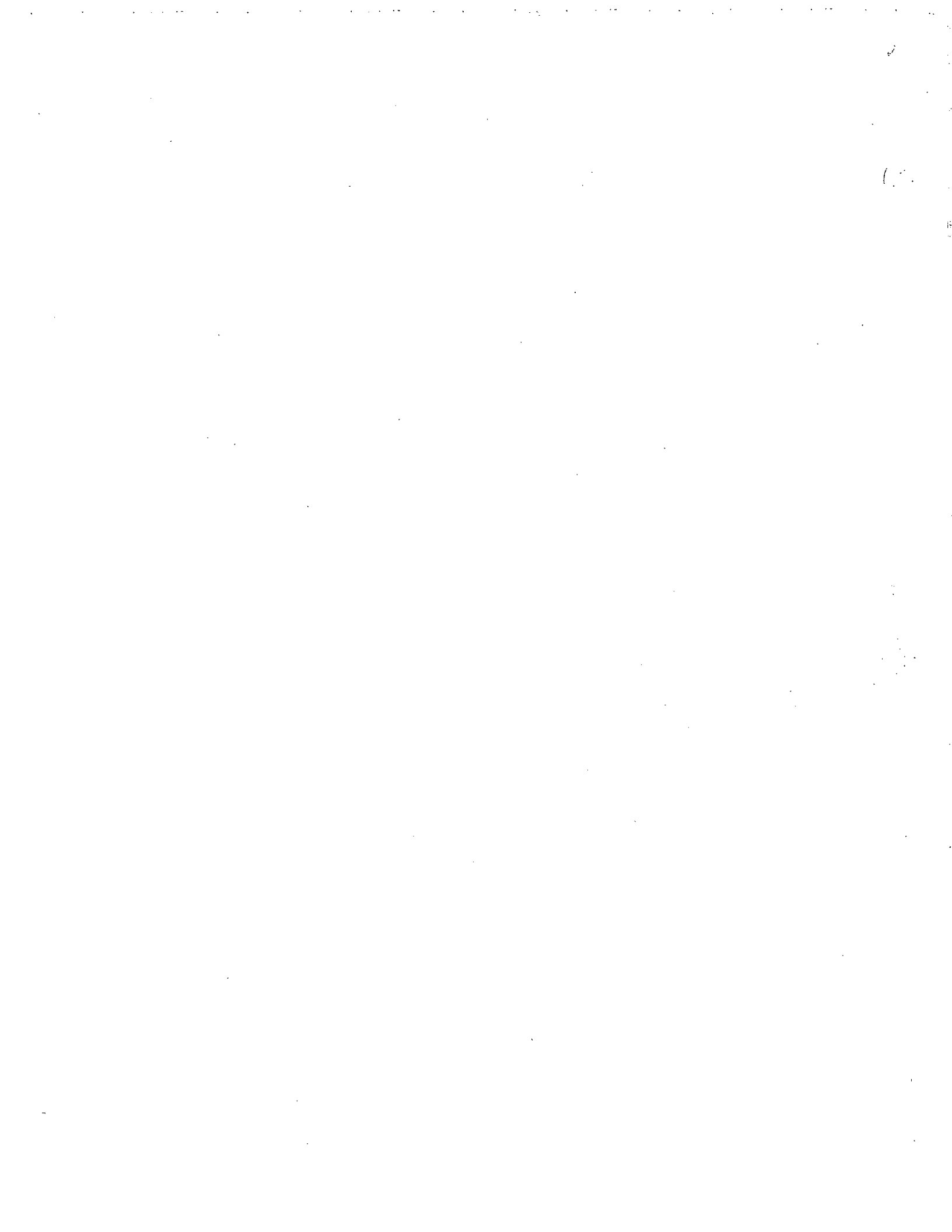
IDENTIFYING DECOMPOSITION REACTIONS

Ten chemical equations are listed below. Some are decomposition reactions. Some are not. Mark a (✓) in the correct box next to each equation.

| | Equation | Decomposition Reaction | Not a Decomposition Reaction |
|-----|--|------------------------|------------------------------|
| 1. | $\text{CuCl}_2 \rightarrow \text{Cu} + \text{Cl}_2$ | | |
| 2. | $3\text{Hf} + 2\text{N}_2 \rightarrow \text{Hf}_3\text{N}_4$ | | |
| 3. | $\text{Zn} + 2\text{HCl} \rightarrow \text{ZnCl}_2 + \text{H}_2$ | | |
| 4. | $\text{H}_2\text{CO}_3 \rightarrow \text{H}_2\text{O} + \text{CO}_2$ | | |
| 5. | $2\text{NaOH} \rightarrow 2\text{Na} + \text{O}_2 + \text{H}_2$ | | |
| 6. | $\text{Fe} + \text{S} \rightarrow \text{FeS}$ | | |
| 7. | $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$ | | |
| 8. | $4\text{P} + 5\text{O}_2 \rightarrow 2\text{P}_2\text{O}_5$ | | |
| 9. | $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$ | | |
| 10. | $\text{Ca}(\text{OH})_2 \rightarrow \text{CaO} + \text{H}_2\text{O}$ | | |

REACHING OUT

1. Does boiling decompose water? _____
2. What does boiling do to water? _____



LESSON 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."



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.



The reaction produces a new compound, zinc chloride (ZnCl₂), and free hydrogen (H₂). 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

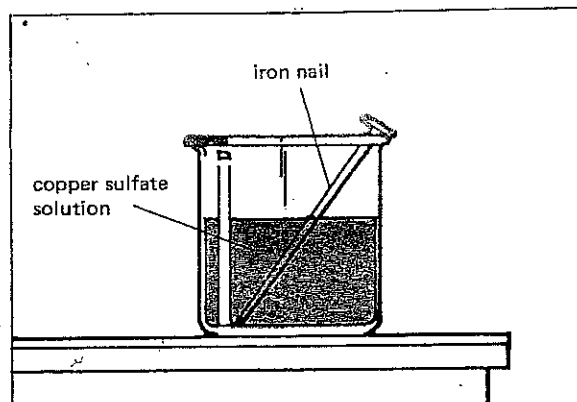


Figure A



Figure B

What You Need (Materials)

iron nail
copper sulfate solution
beaker

How To Do The Experiment (Procedure)

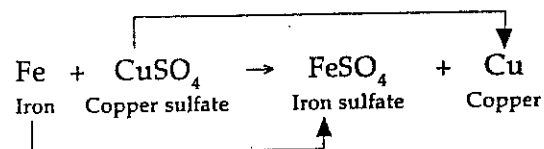
Place an iron nail in copper sulfate solution.

Remove the nail in a few minutes.

What You Saw (Observations)

The nail is coated with copper.

This is the equation for the reaction.



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? _____

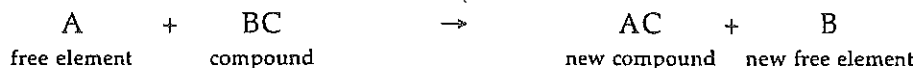
IDENTIFYING SINGLE REPLACEMENT REACTIONS

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. | $C + 2S \rightarrow CS_2$ | | |
| 2. | $H_2O_2 \rightarrow H_2 + O_2$ | | |
| 3. | $2Al + 6HCl \rightarrow 2AlCl_3 + 3H_2$ | | |
| 4. | $2K + Cl_2 \rightarrow 2KCl$ | | |
| 5. | $Zn + PbO \rightarrow ZnO + Pb$ | | |
| 6. | $Fe + CuSO_4 \rightarrow FeSO_4 + Cu$ | | |

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.



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

Let us 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.

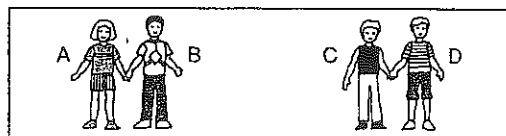


Figure C

Child A changes place with child C.

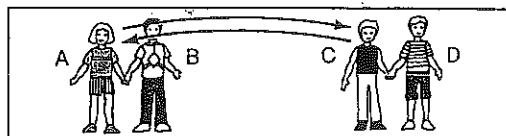


Figure D

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

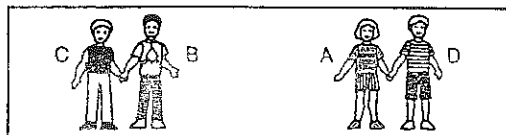
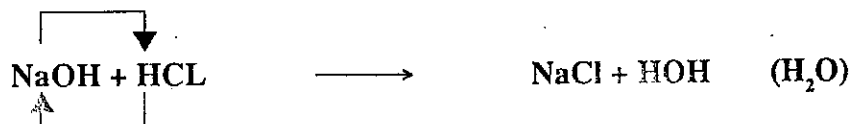


Figure E

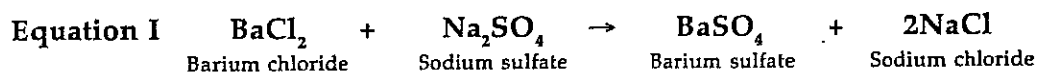
When there are two changeovers, a double replacement has taken place.

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



- 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.



- Name the reactants. _____
- The reactants are _____
both elements, both compounds, an element and a compound
- The barium changed places with the _____
sulfate, chlorine, sodium
- Name the products. _____
- The products are _____
both elements, both compounds, an element and a compound
- What kind of chemical reaction is this? _____
- Double replacement is the reaction of two _____ to form two new _____



- Name the reactants. _____
- The reactants are _____
both elements, both compounds, an element and a compound
- The silver changed places with the _____
sodium, bromine, nitrate
- Name the products. _____
- The products are _____
both elements, both compounds, an element and a compound
- What kind of chemical reaction is this? _____

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. | $\text{Mg}(\text{OH})_2 + 2\text{HCl} \rightarrow \text{MgCl}_2 + 2\text{HOH}$ | | |
| 2. | $\text{C}_6\text{H}_{10}\text{O}_5 + \text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6$ | | |
| 3. | $\text{Na}_2\text{SO}_4 + \text{BaCl}_2 \rightarrow 2\text{NaCl} + \text{BaSO}_4$ | | |
| 4. | $3\text{Mg} + \text{N}_2 \rightarrow \text{Mg}_3\text{N}_2$ | | |
| 5. | $\text{H}_2\text{SO}_4 + \text{BaCl}_2 \rightarrow 2\text{HCl} + \text{BaSO}_4$ | | |
| 6. | $\text{ZnCO}_3 \rightarrow \text{ZnO} + \text{CO}_2$ | | |
| 7. | $\text{CuSO}_4 + \text{H}_2\text{S} \rightarrow \text{H}_2\text{SO}_4 + \text{CuS}$ | | |
| 8. | $\text{NH}_4\text{NO}_3 \rightarrow 2\text{H}_2\text{O} + \text{N}_2\text{O}$ | | |

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. | $\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$ | |
| 2. | $2\text{Br}_2 + 2\text{H}_2\text{O} \rightarrow 4\text{HBr} + \text{O}_2$ | |
| 3. | $\text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$ | |
| 4. | $2\text{KBr} + \text{H}_2\text{SO}_4 \rightarrow \text{K}_2\text{SO}_4 + 2\text{HBr}$ | |
| 5. | $\text{H}_2\text{SO}_3 \rightarrow \text{H}_2\text{O} + \text{SO}_2$ | |
| 6. | $\text{Na}_2\text{S} + 2\text{HCl} \rightarrow 2\text{NaCl} + \text{H}_2\text{S}$ | |
| 7. | $2\text{Na} + \text{I}_2 \rightarrow 2\text{NaI}$ | |
| 8. | $\text{NaCl} + \text{AgNO}_3 \rightarrow \text{NaNO}_3 + \text{AgCl}$ | |
| 9. | $\text{H}_2 + \text{Cl}_2 \rightarrow 2\text{HCl}$ | |
| 10. | $\text{H}_2\text{CO}_3 \rightarrow \text{H}_2\text{O} + \text{CO}_2$ | |



LESSON 18

What happens when acids and bases are mixed?

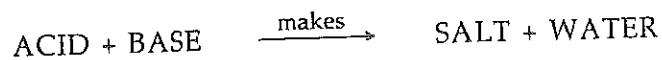
In chemistry, a liquid is neutral if it is not an acid nor a base. Take water, for example. Water is neutral. It is not an acid. It is not a base.

Acids and bases have definite properties. In many ways they are opposite. What happens if you mix an acid with a base?

When you mix an acid with a base, a chemical reaction takes place. The atoms from the acid and the base change the way they are linked up. New products are formed. These new products have their own properties. The properties are different from the properties of either acids or bases.

What do you get?

When you mix the right amounts of an acid and a base, you get a salt and water. The salt is dissolved in the water. It forms a salt solution. A salt solution is not an acid: it is not a base. It is neutral.



The link-up of an acid and a base to form a salt and water is called **neutralization** [new-truh-li-ZAY-shun].

There are many kinds of salts. The salt you sprinkle on your food is just one kind of salt called sodium chloride. Its formula is NaCl. Different salts have different formulas.

MIXING AN ACID AND A BASE

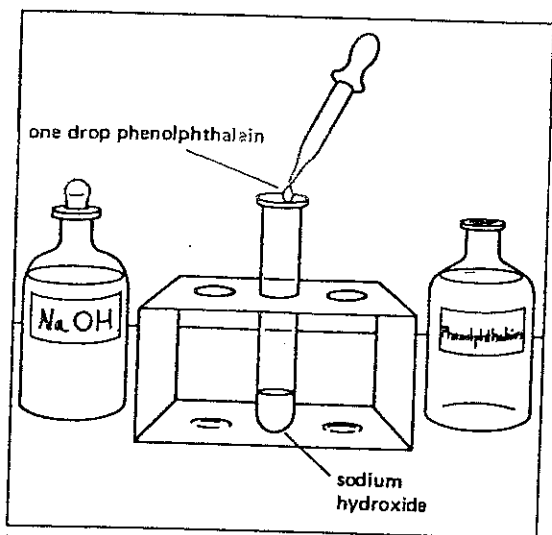


Figure A

The test tube in Figure A contains twenty drops of sodium hydroxide (NaOH).

One drop of phenolphthalein is added. The phenolphthalein turns deep pink.

This shows that sodium hydroxide (NaOH)

is _____
an acid, a base

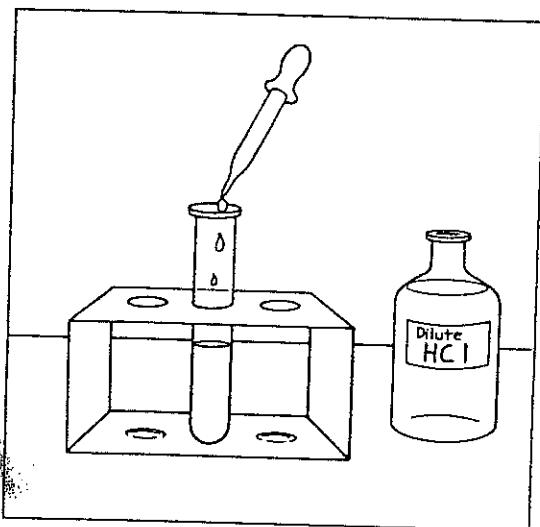


Figure B

A different dropper is used in Figure B to add fifteen drops of hydrochloric acid (HCl) — one drop at a time.

The solution stays pink.

This show that the solution

_____ is neutral, is an acid, is still a base

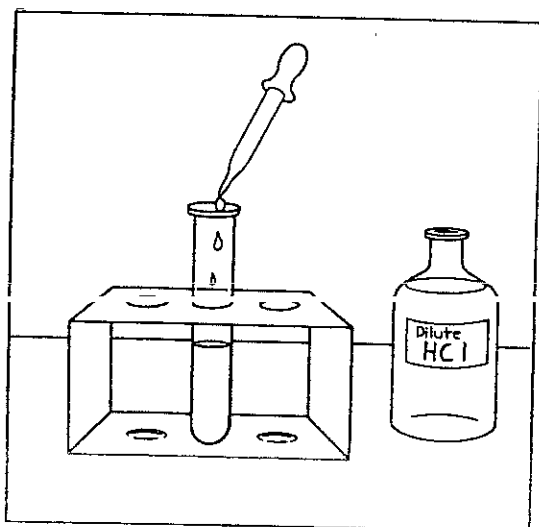


Figure C

More hydrochloric acid (HCl) is added — one drop at a time, until the pink disappears.

The loss of the pink color shows that the

solution is _____
an acid, no longer a base

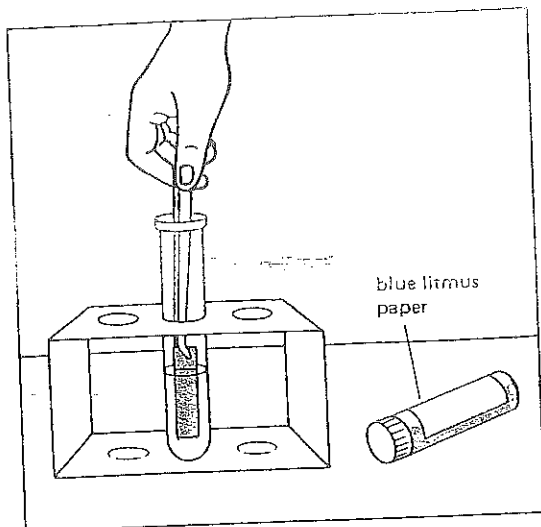


Figure D

The solution is tested with blue litmus paper.

The blue litmus paper stays blue.

This shows that the solution is not

_____ an acid, a base

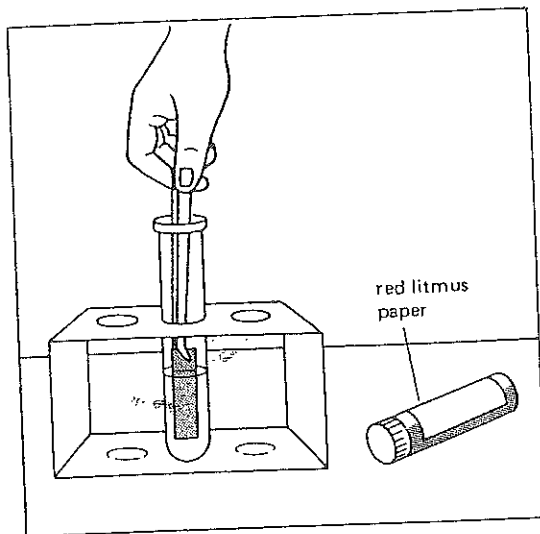


Figure E

The solution is tested with red litmus paper.

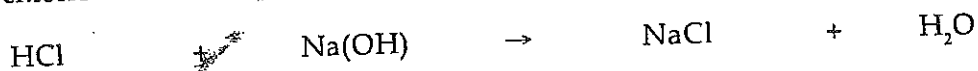
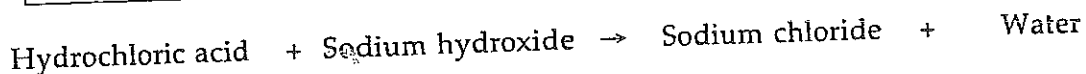
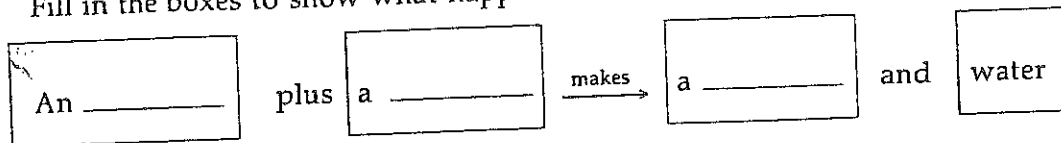
The red litmus paper stays red.

This shows that the solution is not

_____ an acid, a base

The mixture _____ neutral.
is, is not

Fill in the boxes to show what happened:



NaCl in H₂O is _____
an acid, a base, salt water.

FILL IN THE BLANK

Complete each statement using a term or terms from the list below. Write your answers in the spaces provided. Some words may be used more than once.

water
neutralization
litmus paper
an acid

a base
many kinds
reaction
a salt

table
neutral
phenolphthalein

1. Lemon juice is an example of _____. Lye is an example of _____.
2. Any substance that is not an acid nor a base is said to be _____.
3. An example of a neutral liquid is _____.
4. The mixing of an acid and a base causes a chemical _____.
5. If we mix the right amounts of an acid and a base, we get _____ and _____.
6. The chemical reaction between an acid and a base to produce a salt and water is called _____.
7. There are _____ of salts.
8. The most common salt is _____ salt.
9. Salt water does not change the color of _____
or _____.
10. Salt water is neither _____ nor _____. Salt water is _____.

MATCHING

Match each term in Column A with its description in Column B. Write the correct letter in the space provided.

Column A

- _____ 1. HCl
_____ 2. NaOH
_____ 3. H₂O
_____ 4. NaCl
_____ 5. phenolphthalein

Column B

- a) acid
b) water
c) base
d) indicator
e) salt

TRUE OR FALSE

In the space provided, write "true" if the sentence is true. Write "false" if the sentence is false.

- _____ 1. An acid is neutral.
- _____ 2. A base is neutral.
- _____ 3. Water is neutral.
- _____ 4. There is only one formula for water.
- _____ 5. There is only one kind of salt.
- _____ 6. Salt water is neutral.
- _____ 7. If you mix an acid with a base, you get only water
- _____ 8. Blue litmus paper changes to red in salt water.
- _____ 9. Red litmus paper stays red in salt water.
- _____ 10. Phenolphthalein turns pink in salt water.

REACHING OUT

When hydrochloric acid reacts with potassium hydroxide, potassium chloride is formed.

- The formula for hydrochloric acid is HCl.
- The formula for potassium hydroxide is KOH.

What is the formula for water? _____

What is the formula for potassium chloride? _____

