Simple Chemical Reactions

A SourceBook Module

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ChemSource

Instructional Resources for Preservice and Inservice Chemistry Teachers

Place in the Curriculum

The investigation of reactions as outlined in this module can come very early in the course. Laboratory activities and demonstrations create interest and provide an experiential basis for the study of later topics such as moles, atomic theory, electronic structure, and acids and bases. The topic of classification of reactions can be revisited later in the year when students can apply a greater knowledge base.

Central Concepts

1. Chemical reactions are recognized by changes in the properties of the species involved.
2. Many chemical reactions can be classified, at the simplest level, according to general kinds of change involved:

$A + B \rightarrow AB$	Synthesis
$AB \rightarrow A + B$	Decomposition
$AB + C \rightarrow AC + B$	Replacement
$AB + CD \rightarrow AD + CB$	Double replacement

3. A chemical equation represents, in symbolic terms, the overall change in a chemical reaction at the atomic and molecular level (words, symbols, pictures in the mind).
4. All chemical equations must be "balanced" to be consistent with the Law of Conservation of Matter.

Related Concepts

1. Chemical Formulas and Symbols
2. Law of Conservation of Mass
3. Elements, Compounds, Substances, Mixtures
4. States of Matter

Related Skills

1. Observe changes that occur in the laboratory
2. Use a balance
3. Light and use a burner safely
4. Recognize equation patterns

Performance Objectives

After completing their study of chemical reactions, students should be able to:

1. write correct formulas given ion charges.
2. interpret formulas.
3. classify a given chemical equation as synthesis, decomposition, single replacement, or double replacement.
4. recognize a chemical change in a laboratory setting.
5. apply the Law of Conservation of Mass to an experiment involving a chemical change.
6. balance equations by inspection.
7. complete simple chemical equations of the types listed earlier in this module.
8. convert a word equation into a symbolic equation.
9. draw "pictures in the mind" to represent the types of chemical reactions listed in this module.

4. Use a test-tube holder to hold the test-tube nearly horizontal. Move it back and forth through a cool flame (no inner blue cone) so that the entire sample is heated. Make observations while heating as well as after you are finished. (You have heated too much if the solid begins to darken.) Heating will be completed after about 2 min.
5. Allow the test-tube and contents to cool and determine its mass.
6. Use your dropper to add a drop of water to the substance in the test-tube. Record your observations.
7. Dispose of the chemicals as your teacher directs.
8. Repeat this part of the activity with calcium chloride hexahydrate, $CaCl_2{\cdot}6H_2O(s)$ or ammonium carbonate, $(NH_4)_2CO_3(s)$.

Part III

1. Place 5 mL copper(II) sulfate solution, $CuSO_4(aq)$, in a large test-tube (16 x 150 mm). Add a strip of magnesium, Mg. Make observations immediately and after 5 min.
2. Place 5 mL hydrochloric acid solution, HCl(aq), in a large test-tube. Add one piece of zinc, Zn. Make observations immediately and after 5 min.
3. Dispose of the chemicals as your teacher directs.

Part IV

1. Pour 3 mL barium chloride solution, $BaCl_2(aq)$, in a test-tube (13- x 100-mm). Add 3 mL sodium sulfate solution, $Na_2SO_4(aq)$.
2. Pour 3 mL cobalt(II) nitrate solution, $Co(NO_3)_2(aq)$, in a test-tube (13- x 100-mm). Add 3 mL sodium phosphate solution, $Na_3PO_4(aq)$.
3. Dispose of the chemicals as your teacher directs.
4. Thoroughly wash your hands before leaving the laboratory.

Data Analysis and Concept Development

Part I

1. What evidence do you have for chemical change in each reaction?
2. Account for the change in mass in each reaction.
3. What characteristics do the reactions have in common?
4. Write a word equation to summarize what happened in each of the chemical changes.
5. Write a symbol equation for the reaction that took place. Look up the formulas if necessary.
6. This type of reaction is sometimes called *synthesis* or *combination*. Explain why this is an appropriate name.

Part II

Answer Questions 1-5 (from *Part I*) for these two reactions.

6. This type of reaction is called *decomposition*. Explain why this is an appropriate name.

LABORATORY ACTIVITY: TEACHER NOTES

Activity 1: Types of Reactions

Level

General or basic student

Major Chemical Concept

Many chemical reactions can be classified into four types—Synthesis, Decomposition, Single Replacement, Double Replacement.

Expected Student Background

Students should be able to use a balance and burner correctly.

Time

45 min

Safety

See *Student Version*

Materials (For 24 students working in pairs)

Nonconsumables

- 24 Test-tubes, 16- x 150-mm
- 48 Test-tubes, 13- x 100-mm, or twelve 24-well spot plates
- 12 Burners
- 12 Tongs
- 12 Test-tube holders
- 12 Medicine droppers

Consumables

- Copper wool, 12 g
- Steel wool, 12 g
- Zinc metal, 6 g
- Magnesium ribbon, 0.6 g (36 cm)
- Copper sulfate, $CuSO_4{\cdot}5H_2O$, 18 g
- Calcium chloride, $CaCl_2{\cdot}6H_2O$, 18 g
- Ammonium carbonate $(NH_4)_2CO_3$, 18 g
- 3 M Hydrochloric acid, HCl, 60 mL (25 mL conc. HCl diluted to 100 mL)
- 0.1 M Copper sulfate, $CuSO_4$, 60 mL (2.5 g $CuSO_4{\cdot}5H_2O$ diluted to 100 mL)
- 0.1 M Barium chloride, $BaCl_2$, 36 mL (2.4 g $BaCl_2{\cdot}2H_2O$ diluted to 100 mL)
- 0.1 M Sodium sulfate, Na_2SO_4, 36 mL (3.2 g $Na_2SO_4{\cdot}10H_2O$ diluted to 100 mL)
- 0.1 M Cobalt nitrate, $Co(NO_3)_2$, 36 mL (2.9 g $Co(NO_3)_2{\cdot}6H_2O$ diluted to 100 mL)
- 0.1 M Sodiumphosphate, Na_3PO_4, 36 mL (3.8 g $Na_3PO_4{\cdot}12H_2O$ diluted to 100 mL)

Advance Preparation

30 min to prepare solutions. Concentrations are not critical. Other concentrations may be substituted if available.

Pre-Laboratory Discussion

Review the evidence for chemical change. You may wish to demonstrate reactions that exhibit the types of evidence that students can use to decide whether a chemical reaction has occurred. Project Seraphim “Periodic Table” videodisc or ACS “Closeup on Chemistry” videodisc present excellent reactions.

5. See equations in *Post-Laboratory Discussion*.
6. Two substances were made from a single substance.

Part III

1. In one reaction a color change occurred and a new solid was formed. In the other, gas bubbles appeared.
2. Not applicable
3. One substance disappeared and another with different properties appeared.
4. Copper(II) sulfate + Magnesium → Copper + Magnesium sulfate
   Hydrochloric acid + Zinc → Hydrogen + Zinc chloride
5. See equations in *Post-Laboratory Discussion*.
6. When looking at the equation one can see that one element replaced another in a compound.

Part IV

1. A precipitate was formed.
2. Not applicable
3. Solutions of two compounds were mixed and a precipitate was formed.
4. Barium chloride + Sodium sulfate → Barium sulfate + Sodium chloride
   Cobalt(II) nitrate + Sodium phosphate → Sodium nitrate + Cobalt(II) phosphate
5. See equations in *Post-Laboratory Discussion*.
6. Looking at the equations and formulas one can see that the positive ions were exchanged. One of the products was insoluble and precipitated.

Answers to Implications and Applications

1. a. Double replacement
   b. Synthesis
   c. Decomposition
   d. Single replacement
2. Most often it is not. One can only observe whether a chemical change has occurred.
3. Names and formulas of starting materials would be very helpful.

Post-Laboratory Discussion

Part I

$$2Cu(s) + O_2(g) \rightarrow 2CuO(s)$$
$$4Fe(s) + 3O_2(g) \rightarrow 2Fe_2O_3(s)$$

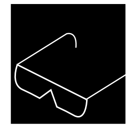
Use logic to show how a decrease in mass or no change in mass would not support the conclusion that a chemical reaction has occurred.

Example: If mass stays the same then the only possibility is copper (reactant) → copper (product), implying no chemical change.

Example: If mass decreases then the only possibility is that copper (reactant) → something less than copper (product); logically that is not possible because copper is an element and is not decomposed in normal chemical reactions. Emphasize the observations of a new product being formed on the surface of the copper wool.

Activity 2: Identifying Products of a Reaction

Laboratory Activity: Student Version



Introduction

The ability to classify chemical reactions helps us to predict the products of the reaction. However, only experimentation can confirm the identity of substances produced in a chemical reaction. In this activity two solutions are mixed to initiate a chemical reaction. The identity of the products is confirmed by flame tests and another chemical reaction.

Purpose

To observe the reaction of calcium chloride and potassium carbonate, predict the products, and confirm the identity of the products.

Safety

1. Wear eye protection throughout the laboratory activity.
2. Hydrochloric acid is caustic and corrosive. If you spill any on your skin wash it off with water and notify the teacher. Skin contact with other chemicals and solutions should be avoided.
3. Dispose of the chemical substances as your teacher directs.

Procedure

Before beginning the laboratory work, read through the entire procedure and prepare a data table. Record all data and observations in the table.

1. Weigh 2.5 g potassium carbonate, K_2CO_3, and 2 g calcium chloride, $CaCl_2$. Place in separate 100-mL beakers.
2. Add 25 mL distilled water to each beaker. Stir until all the solid is dissolved.
3. Number four 13 x 100-mm test-tubes from 1 to 4. Put 2 mL potassium carbonate solution in Tube 1 and 2 mL calcium chloride solution in Tube 2. Place a clean splint in Tubes 1 and 2.
4. Fold a piece of filter paper to fit the funnel.
5. Add the remaining solution of potassium carbonate to the remaining solution of calcium chloride. When the reaction is complete, filter the solution with pleated filter paper to hasten filtration. Remove the filtrate and wash the precipitate with 10 mL distilled water. If the filtrate is cloudy, filter again through the same filter paper.
6. Place 2 mL filtrate and a clean splint in Tube 3.
7. With a clean splint remove a small amount of precipitate from the filter paper. Put the splint and the solid in Tube 4. Add 2 mL distilled water.
8. Perform flame tests by holding each wet splint from Tubes 1-4 in the burner flame. Observe the first color you see. *Do not allow the splint to burn.* Dispose of the splints in the trash can.
9. Add three drops 3 M hydrochloric acid, HCl, to each solution in the test-tubes. Formation of bubbles indicates that the carbonate ion, CO_3^{2-}, was originally present.
10. If your teacher directs, set aside some of the filtrate to observe the crystals that form.

Laboratory Activity: Teacher Notes

Activity 2: Identifying Products of a Reaction

Level

General or basic student.

Major Chemical Concept

The products of a double replacement reaction can be determined experimentally. The amounts of reactants are equimolar.

Expected Student Background

Students should be familiar with filtration and be able to use a burner safely.

Time

45 min

Safety

See *Student Version*.

Materials (For 24 students working in pairs)

Nonconsumables

- 24 Beakers, 100-mL
- 12 Funnels
- 12 Erlenmeyer flasks, 125-mL
- 48 Test-tubes, 13- x 100-mm
- 12 Burners
- 12 Stirring rods
- 12 Graduated cylinders, 25-mL
- 12 Blue cobalt glass squares, if available, for viewing the potassium flame test.

Consumables

- Calcium chloride, $CaCl_2$, 24 g
- Potassium carbonate, K_2CO_3, 30 g
- Filter paper
- 3 M Hydrochloric acid, HCl, 12 mL (25 mL conc. HCl diluted to 100 mL)
- 48 Splints

Advance Preparation

20 min to assemble the materials.

Pre-Laboratory Discussion

Review the evidence for chemical change and double replacement reactions. Emphasize that the only way we can be sure about the identity of products is to test them. Discuss flame tests if students are unfamiliar with them. The only use of the flame test in this activity is to identify potassium and calcium ions.

Teacher-Student Interaction

During the activity focus students' attention on the difference in properties of the reactants and products. Caution them to observe the flame test before the splint catches on fire. They should compare the colors of the flame tests on the known starting materials and the products.

Possible Extensions

1. Students may plan an investigation to determine the identity of products produced in one of the demonstrations that follow this section.
2. The use of flame tests as an identification tool may be studied further.

Assessing Laboratory Learning

1. Extension 1 could serve as an evaluation. Be sure to use reactions involving chemistry that students can reasonably be expected to know.
2. Pictures in the Mind of different systems (Example: Demonstration 3) can be used to evaluate whether students have a reasonable concept of what occurs at the molecular level.

DEMONSTRATIONS

Purpose

These demonstrations allow students to observe a wide variety of chemical reactions, most of which should not be performed by students for safety reasons. Be sure to keep students actively involved by directing them to make observations and consider questions during demonstrations. They could be asked to write down observations.

Safety

Wear eye protection and an apron throughout the demonstrations. Thoroughly wash your hands after concluding the demonstrations. Additional safety precautions are given for each demonstration.

Demonstration 1: Magnesium Burning

Materials

Magnesium ribbon, Mg, 3-5 cm strip
Burner
Crucible tongs

Safety

Caution students not to look at flame directly.

Directions

Light the burner. While holding the magnesium with the crucible tongs, light the magnesium in the burner flame. Point out the evidence that a reaction has occurred.

$$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$$

Demonstration 2: A Penny in Nitric Acid

Materials

Erlenmeyer flask, 1000-mL
Penny, pre-1983
Conc. Nitric acid, HNO_3, 30 mL

Safety

Conduct the reaction in the hood—the fumes are toxic. Nitric acid is highly corrosive.

Safety

This reaction is striking and demonstrates vividly to students that chemical reactions not only result in a change in properties, but also often release energy. However, be aware that *without the precautions specified here, this demonstration can be dangerous.*

Directions

Fill the Petri dish about half full with cold water. Be sure that the water is *cold* and the piece of sodium is no larger than a grain of uncooked rice. Drop the piece of sodium into the water. Observe the reaction. Sometimes the generated hydrogen will actually burn. Small scrapings or cuttings of sodium may be disposed of by dropping them in alcohol. Some chemical companies that supply schools sell an alloy of approximately 10% sodium and 90% lead that can be used in place of pure sodium.

$$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$$

Demonstration 6: Endothermic Reaction

Materials

Barium hydroxide, $Ba(OH)_2$, 10 g
Ammonium thiocyanate, NH_4SCN, 10 g
Erlenmeyer flask, 250-mL

Safety

Properly dispose of the products.

Directions

Place the barium hydroxide in the flask. [*CAUTION: $Ba(OH)_2$ is* very *toxic.*] Add the ammonium thiocyanate. Swirl the two solids for about 20-30 sec. Give the flask to a student to hold. Evidence for the reaction is an unexpectedly cold container, indicating an endothermic process.

$$Ba(OH)_2(s) + 2NH_4SCN(s) \rightarrow 2NH_3(g) + H_2O(l) + Ba(SCN)_2(s)$$

Demonstration 7: Floating Pennies

Materials

Pennies minted after 1983
6 M Hydrochloric acid, HCl
Large graduated cylinder

Safety

Hydrochloric acid is a corrosive substance.

Directions

Pour hydrochloric acid into the cylinder so it is about 3/4 full. Use a triangular file to scrape the edge of each penny to expose the zinc core. It seems to work best to scrape twice—on opposite edges of the penny. Drop the pennies into the hydrochloric acid. Bubbles will be seen immediately, but the pennies exhibit unusual behavior after about 24 hours. They will float and sink as their density approaches that of the surrounding acid. The hollow pennies are also interesting to examine after the reaction is completed. You can prepare “day old” pennies for this purpose.

$$Zn(s) + 2HCl(aq) \rightarrow H_2(g) + ZnCl_2(aq)$$

Group and Discussion Activities

Key Questions

1. What evidence can be observed to indicate that a chemical change has occurred?
[Color change, change in physical state, energy absorbed or released.]
2. Why is it useful to be able to classify chemical reactions?
[Classification enables us to organize information and ultimately to predict the results of similar types of changes.]
3. Is there only one type of classification that might be used for chemical reactions?
[No, there are many different ways to classify reactions. Many of these will be used as knowledge of chemistry increases. It is always necessary to state the criteria used for the classification.]
4. What future classification schemes are suggested by this study?
[Is energy absorbed or released? How fast is the reaction? What kind of products are produced? What kind of process is involved in the change?]

Pictures in the Mind

Which pictures in Figure 1 represent:

a. Elements
b. Solids
c. Gases
d. Compounds
e. Precipitates
f. Gaseous elements
g. Solid elements
h. Liquid elements

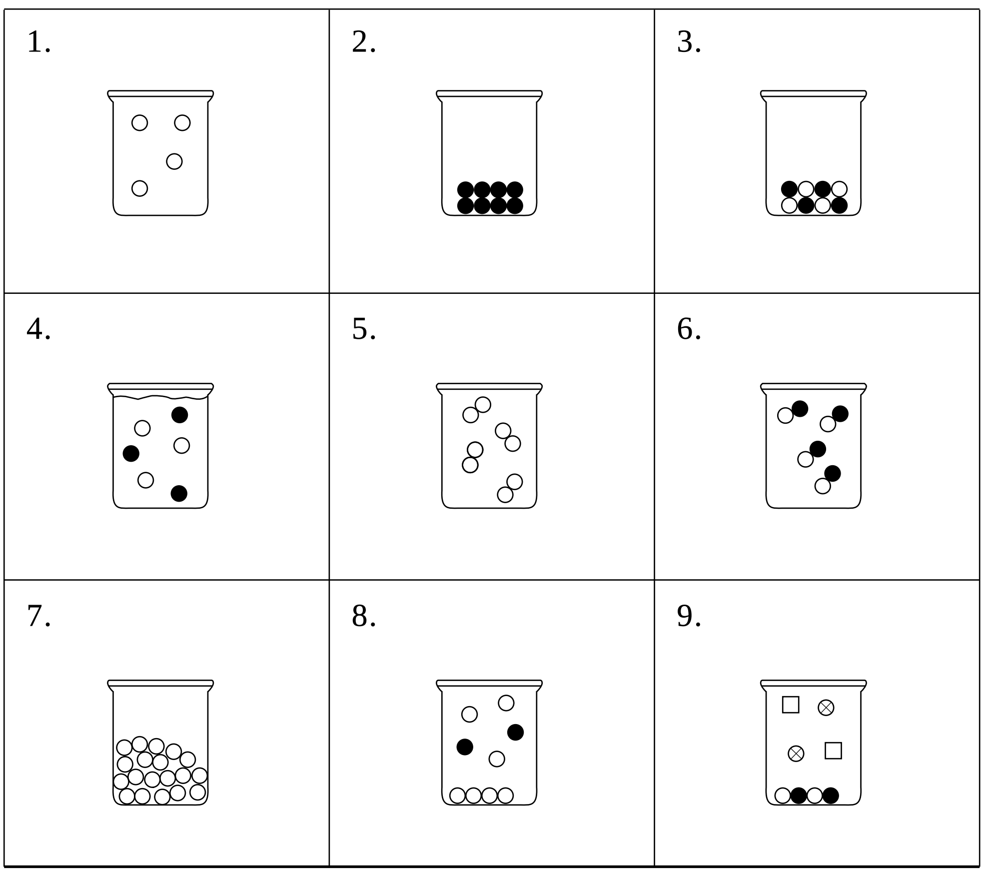


Figure 1. Representation of "Pictures in the Mind." *These molecular conglomerates can be made from Perler's "Big Beads for Little Fingers" (available at craft shops) and suspended in a beaker by thread from cardboard or a heavy paper lid.*

single replacement reaction reaction in which one element replaces another.

solution homogeneous mixture.

substance sample of matter that has a uniform set of properties and a definite composition. Examples of substances are elements and compounds.

synthesis reaction two or more substances form a single substance in a reaction. Synonyms are "composition" and "combination."

Pattern Recognition

Teaching students to classify reactions is an exercise in pattern recognition.

Synthesis (combination; composition)

Element + Element → Compound

1. Iron + Sulfur → Iron(II) sulfide
2. Mercury + Oxygen → Mercury(II) oxide
3. Phosphorus + Oxygen → Diphosphorus pentoxide
4. Potassium + Chlorine → Potassium chloride

Compound + Compound → More complex compound

1. Magnesium oxide + Carbon dioxide → Magnesium carbonate
2. Sulfur dioxide + Water → Sulfurous acid

Decomposition

Compound → Two or more simpler substances

1. Water → Hydrogen + Oxygen
2. Calcium carbonate → Calcium oxide + Carbon dioxide
3. Sodium nitrate → Sodium nitrite + Oxygen
4. Copper(II) sulfate pentahydrate → Copper(II) sulfate + Water

Single replacement

Element + Compound → Element + Compound

1. Iron(III) oxide + Carbon → Iron + Carbon monoxide
2. Aluminum + Sulfuric acid → Aluminum sulfate + Hydrogen
3. Copper(II) sulfate + Iron → Copper + Iron(II) sulfate
4. Sodium + Water → Sodium hydroxide + Hydrogen

Double replacement

Two compounds → Two new compounds

1. Sodium carbonate + Calcium hydroxide → Sodium hydroxide + Calcium carbonate
2. Iron(II) sulfide + Hydrochloric acid → Hydrogen sulfide + Iron(II) chloride
3. Magnesium hydroxide + Sulfuric acid → Water + Magnesium sulfate
4. Copper(II) nitrate + Sodium hydroxide → Copper(II) hydroxide + Sodium nitrate

Pictures in the Mind

"Pictures in the mind" is a useful device to help students understand on a molecular level what is happening when a chemical reaction occurs. If attention is paid to the numbers of atoms that combine to form new substances and to balancing equations, it may help students later to attack the challenging (for many) subject of stoichiometry. Be sure to include containers for the pictures so students do not acquire incorrect ideas of solids and liquids. If you have not already introduced pictures for solids, liquids, gases, compounds, and elements, do so before reactions are considered.

Solids:
Units touching and organized

Liquids:
Units touching but not organized

Gases:
Space between units (molecules)

Solutions:
Units separated by solvent molecules

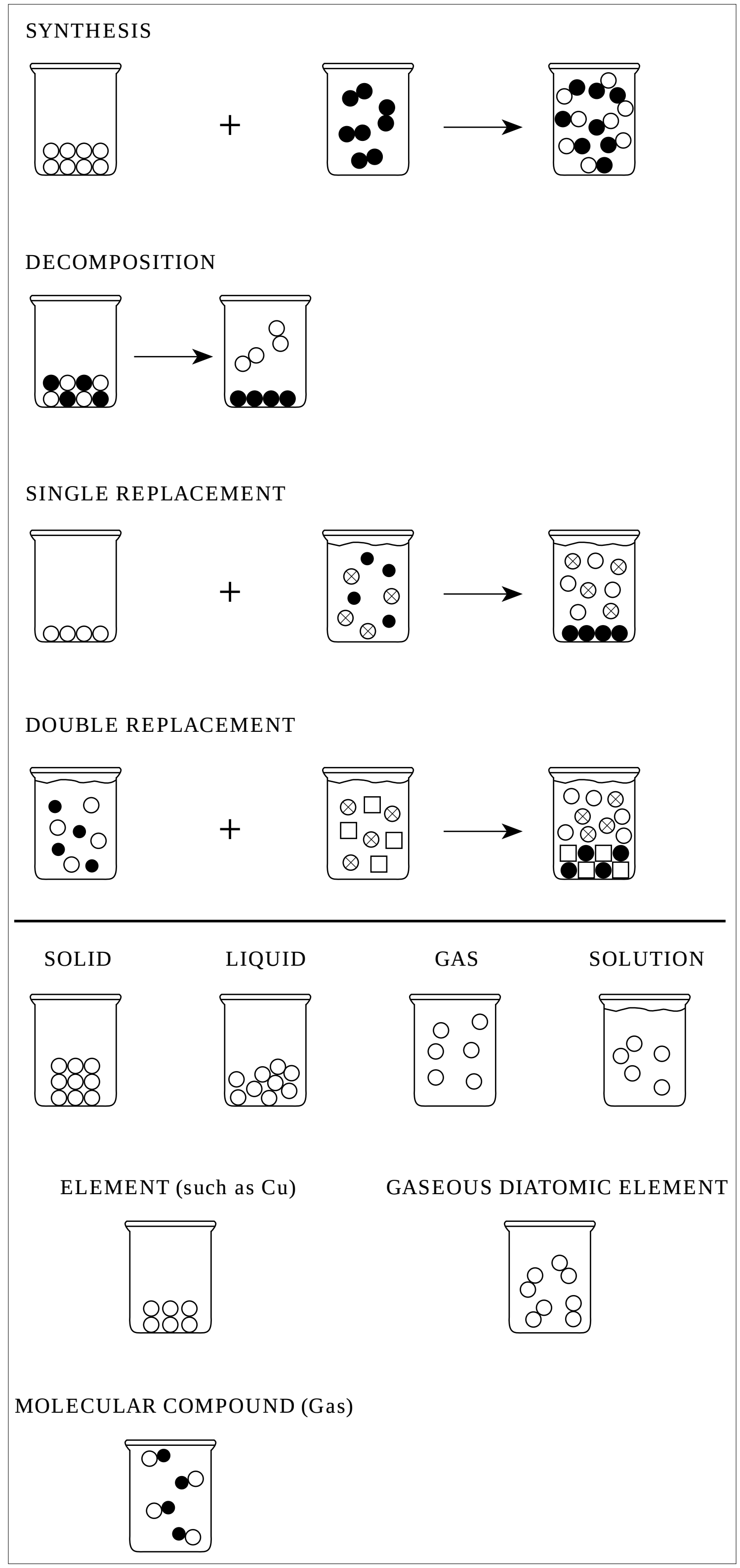


Figure 2. Pattern recognition for "Pictures in the Mind."

HUMOR: ON THE FUN SIDE

1. Message on a T-shirt: Looking for a reaction? Try me—I'm a chemist.

2. **THE H_2 OF AN O**

One thing I would like to do
Is draw a character sketch of CO_2...
Meet an angry LiH perhaps,
Or talk to a placid He gas...
Find an NaH that likes to play
And picnic on a sunny day,
Or an NO_3 that moaned and cried
When his kindly mother, HNO_3, died.
The world could hold
    Satisfied Ne's
    Capitalist Rb's
    Socialist Pb's.

But then of course, on cloudy days
The H_2's would go off to war
And cruelly spread their acid horror
Among the lowly SO_4.

Yes, good is mixed with evil:
That is the way of life.
And if we're to have friendly O's
We must have H_2 strife.

Au bless us, every mole.

CHEM 13 NEWS, April 1969, p. 41

3. **CHEMISTRY ROCK**

Chemistry, Chemistry, Chemistry Rock
We're so scientific, the work never stops
We balance equations around the clock
That's the Chemistry Rock!

Seventh bell time[1] is a swell time
To rock the lab away
Computations, calculations
Well, Mr. Evans[2] might give you an "A"

So listen here, lend an ear and we'll tell you why
It's chemistry at the top
It'll keep your mind working overtime
That's the Chemistry Rock!

[1]Put in your own time.

[2]Put in your teacher's name.

CHEM 13 NEWS, February 1982, p. 12

5. Word Search (see *Appendix* for master copy)

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S Z E T I N A E J P F O Q I W W P
F Y C R U L C O M P O U N D T T R
Z G N E X Y M M U G V K Q E C E E
U Z A T E C C X Y A B P W D Y L C
X S T E H Y X N O I T A U Q E W I
R M S Q X E Y G X V T H I M P B P
E P B W A J S W V D Y W E V A X I
A L U K H E D I C Y A N G K Q U T
C Y S B K G M I S X T B K G U T A
T J M Q X J C X B S A M N N E J T
I F G M I X T U R E K U C U O N E
O R M Q A H H T D A C R D W U G T
N O I T I S O P M O C E D B S V Q
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Words about the concepts in this module can be obtained from the clues given. Find these words in the block of letters:

1. Solid formed in a chemical reaction involving solutions.
2. Substance that cannot be decomposed into a simpler substance.
3. Reaction type in which two or more substances form a single substance in a reaction.
4. Reaction type in which two or more substances are formed from a single substance.
5. Process by which one or more substances change into new substances.
6. Two or more substances that are not chemically combined and do not have a fixed set of properties.
7. Substance composed of two or more elements.
8. Sample of matter that has a uniform set of properties and a definite composition.
9. Symbolism used to represent reactions that occur.
10. Adjective for a water solution.

Answers: 1. PRECIPITATE 2. ELEMENT 3. SYNTHESIS 4. DECOMPOSITION 5. REACTION 6. MIXTURE 7. COMPOUND 8. SUBSTANCE 9. EQUATION 10. AQUEOUS

6. See cartoons at end of module.

MEDIA

1. *Doing Chemistry* videodiscs are devoted to demonstrating chemical reactions. The wide variety and extensive list of chemical reactions make this an important teacher resource. "Reactions in a Bag," Experiment D45, provides an excellent introduction to the whole topic. Available from American Chemical Society, 1155 Sixteenth Street, N.W., Washington, DC 20036.
2. The *World of Chemistry* videotapes. World of Chemistry Videocassettes. Annenberg/CPB Project, P.O. Box 1922, Santa Barbara, CA 93116-1922; (800) 532-7637; World of Chemistry Series, Atlantic Video, 150 South Gordon Street, Alexandria, VA 22304; (703) 823-2800 or QUEUE Educational

6. *Closeup on Chemistry*, videodisc available from the American Chemical Society, 1155-16th Street, NW, Washington, DC 20036.
7. Concepts in General Chemistry Series, *Chemical Reactions* and *Reactions in Aqueous Solution*. Trinity Software, P.O. Box 960, Campton, NH 03223; (800) 352-1282.1.

4. Rusting of iron and steel is a chemical reaction readily recognized by everyone. Overall, it can be classified as a synthesis reaction.

   $$4Fe(s) + 3O_2(g) + 6H_2O(l) \rightarrow 2Fe_2O_3{\cdot}3H_2O(s)$$

   The product, rust, is a hydrated form of iron(III) oxide. The actual sequence of reactions that yields this overall change is quite complex, and not yet completely understood. An interesting characteristic is that the process is catalyzed by salt. One possible explanation of most of the data is as follows.

   The metallic iron in contact with water is oxidized

   $$Fe \rightarrow Fe^{2+} + 2\,e^-$$

   These electrons then reduce O_2 dissolved in the water

   $${}^1/_2O_2 + 2H^+ + 2\,e^- \rightarrow H_2O$$

   The acid needed for this comes from CO_2 dissolved in the water, forming an acidic solution. Concurrently, dissolved O_2 combines with the Fe^{2+} ions as

   $${}^1/_2O_2 + 2Fe^{2+} + 5H_2O \rightarrow Fe_2O_3{\cdot}3H_2O + 4H^+$$

   This last compound is rust, a hydrated form of iron(III) oxide. Essentially the oxygen atom oxidized Fe^{2+} ions to Fe^{3+} ions.

   An interesting feature of the process is that these three reactions (two of them redox half-reactions) can each occur at a different spot on the metal surface. Thus corrosion (the first reaction) can be seen in one spot while rust formation (the third reaction) can be seen at another. It is believed that salt water catalyzes the process by helping to transport Fe^{2+} ions and electrons to different points along the metal surface.

5. Formation of stalagmites and stalactites in *Solubility and Precipitation* module.

6. Space scientists suggest the removal of carbon dioxide from the cabin atmosphere of a space mission by absorption in sodium hydroxide. Since the average human body breathes out about 925 g of carbon dioxide per day, for a six-passenger, 10-day expedition into space, 101 kg of sodium hydroxide would be required.

   $$CO_2(g) + 2NaOH(s) \rightarrow Na_2CO_3(aq) + H_2O(l)$$

7. If astronauts drank an average volume of 2 L of water a day, they would eliminate 2.4 L of water, with the additional amount coming from food metabolism. Scientists suggest that astronauts use lithium oxide (because of its low molar mass) to absorb the water. For the expedition hypothesized above, 240 kg of Li_2O would be needed.

   $$Li_2O(s) + H_2O \rightarrow 2LiOH(aq)$$

   You might try carrying through the stoichiometric calculations.

8. Fermentation, a not so simple chemical reaction, is the basis of the brewing and baking industries.

Appendix

- **Transparency Masters**
  1. Solids, Liquids, Gases: Pictures in the Mind
  2. Word Search
- **Humor**

Word Search

S	Z	E	T	I	N	A	E	J	P	F	O	Q	I	W	W	P
F	Y	C	R	U	L	C	O	M	P	O	U	N	D	T	T	R
Z	G	N	E	X	Y	M	M	U	G	V	K	Q	E	C	E	E
U	Z	A	T	E	C	C	X	Y	A	B	P	W	D	Y	L	C
X	S	T	E	H	Y	X	N	O	I	T	A	U	Q	E	W	I
R	M	S	Q	X	E	Y	G	X	V	T	H	I	M	P	B	P
E	P	B	W	A	J	S	W	V	D	Y	W	E	V	A	X	I
A	L	U	K	H	E	D	I	C	Y	A	N	G	K	Q	U	T
C	Y	S	B	K	G	M	I	S	X	T	B	K	G	U	T	A
T	J	M	Q	X	J	C	X	B	S	A	M	N	N	E	J	T
I	F	G	M	I	X	T	U	R	E	K	U	C	U	O	N	E
O	R	M	Q	A	H	H	T	D	A	C	R	D	W	U	G	T
N	O	I	T	I	S	O	P	M	O	C	E	D	B	S	V	Q

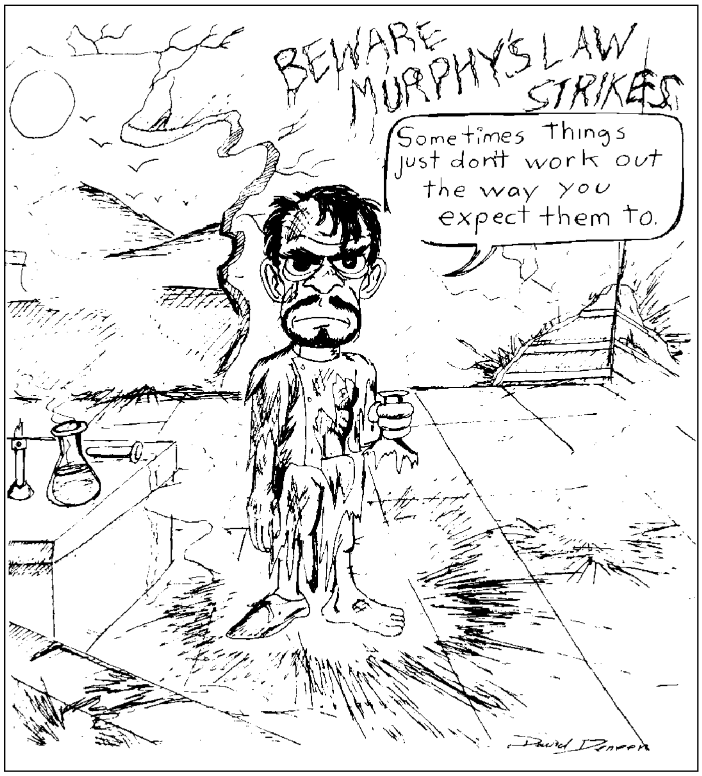
Words about the concepts in this module can be obtained from the clues given. Find these words in the block of letters:

1. Solid formed in a chemical reaction involving solutions.
2. Substance that cannot be decomposed into a simpler substance.
3. Reaction type in which two or more substances form a single substance in a reaction.
4. Reaction type in which two or more substances are formed from a single substance.
5. Process by which one or more substances change into new substances.
6. Two or more substances that are not chemically combined and do not have a fixed set of properties.
7. Substance composed of two or more elements.
8. Sample of matter that has a uniform set of properties and a definite composition.
9. Symbolism used to represent reactions that occur.
10. Adjective for a water solution.

There's old bootsie using a Bunsen Burner same as I did.

CHEMTECH, August 1972, p. 510

CHEM 13 NEWS, February 1982, p. 12CHEM 13 NEWS, February 1982, p. 12. Reprinted with permission.



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