ANALYSIS OF SIMPLE MIXTURES #1300

The objective of this kit is to introduce the student to the study of mixtures and compounds. The materials in the kit allow the student to perform separations of three two-component-unknown mixtures using different physical separation techniques. Five different separation techniques will be used: (1) magnetic separation; (2) size separation; (3) flotation; (4) solubility behavior; and (5) melting/recrystalliztion. The kit is designed for use by both junior high and high school students in physical science courses. Enough material is contained in the kit to allow at least six groups of students to work at the same time.

Contents:

20 Paper Cups (3 ounce)
6 Plastic Cups
6 Plastic Lids
6 Screens
6 Styrofoam Cups (6 ounce)
6 Watch Glasses
6 Spoons
3 Magnets
Mixture A: (Approximate Amounts)
- Sulfur 85 grams
- Polystyrene 10 grams

Mixture B: (Approximate Amounts)
- Iron Filings 175 grams
- Sulfur 100 grams

Mixture C: (Approximate Amounts)
- Salt 160 grams
- Stearic Acid 50 grams

Teacher Manual (1)
Student Instructions Master (1)

Additional Required Materials:

Test Tubes
Bunsen Burners
Test Tube Holders
Liquid Detergent

Refills are available for this kit.

ANALYSIS OF SIMPLE MIXTURES #1300 Teacher Manual

Introduction:

This kit is designed for use by both junior high and high school students in physical science courses as an introduction to the study of mixtures and compounds. This is an important topic in basic physical science, setting the groundwork for understanding more advanced physical and chemical principles. The materials in this kit allow the student to perform separations of several mixtures using different physical separation techniques. Prior knowledge of chemistry is not needed to successfully run the student experiments in this kit. Students should be encouraged to relate the ability to separate mixtures to the differences between physical and chemical reactions. The instructor may want to consider The Science Source Kit #1600, Survey of Chemical Reactions, to survey chemical change and to better understand the chemical and physical changes of matter.

Background Information:

In the study of chemistry, a distinction is made between compounds and mixtures, each being composed of molecules. A compound consists of molecules jointed together through chemical bonding. Compounds do not have the same physical properties as the original components. Water is an example of a compound. Water is composed of two molecules of hydrogen and one of oxygen, both of which are gases. When these molecules are joined under the appropriate conditions, a chemical bond is formed. The result of this bonding is the formation of water, a liquid.

Mixtures are not held together by chemical bonds. The temporary hydrogen bonds and van der Walls forces that develop are quite weak, and are broken by the kinetic energy of the molecules at room temperature. Physically, the components of a mixture are much more easily separated than those of a compound. A mixture can be represented by a mix of salt and pepper. When this salt and pepper mixture is placed in water, the salt will dissolve, leaving the pepper behind.

A compound can be described as homogenous since it contains the same material throughout. A mixture, on the other hand, is heterogenous, and contains different molecules. It is sometimes difficult to see the heterogenous nature of a mixture. For example, air is a mixture, containing many different substances, yet it appears homogenous. Other mixtures, such as granite, consist of materials that are clearly distinguishable from each other.

To distinguish mixtures from compounds, one must try to separate the material into its components. Mixtures are more easily resolved into separate materials than are compounds, since no chemical bonds need to be broken. Simply mixing the materials together again will regenerate the properties of the original mixture. Compounds, however, are very hard to separate, since they cannot be broken down without breaking the chemical bonds. Once the bonds have been broken, they must be reformed to produce the original mixture. A compound cannot be reformed by simply mixing the components together.

Here are some of the physical characteristics that can be used to separate mixtures:

I. Density: Objects of different densities may be separated through a technique called flotation. By placing the mixture in an appropriate liquid (one that does not dissolve any of the components of the mixture) one component may float and the other may sink. Individual molecules and microscopic particles may be separated on the basis of density and total weight. A centrifuge will cause denser, heavier materials to settle out faster than lighter, less dense materials.

II. Solubility Properties: By choosing appropriate solvents, the various components of a mixture can be separated from each other. This technique is especially useful in organic chemistry. An example of the use of solvents would be the separation of a mixture of grease, sugar, and clothing (also known as dirty laundry). Water is a good solvent for sugar, but not for grease or clothing. Adding water to the mixture allows the sugar component to dissolve, and to be washed away. A solvent such as detergent in water, or carbon tetrachloride (dry cleaning), is needed to separate the grease from the clothing. Since neither the water nor the detergent is a good solvent for clothing, that component remains after the separation has been carried out.

III. Phase Change Separation: Just as each material has specific solubility characteristics, it also has characteristic melting and boiling points. By cooling or heating a mixture to an appropriate temperature, various components of the mixture can be separated. Separation of salt from water may be accomplished by either boiling the water away, or by freezing the water and removing the ice which forms. Either method allows a separation of components from each other.

IV. Size Separation: If the materials in the mixture are composed of particles of different sizes, then the mixture may be separated by using techniques related in size. Sifting and filtration are two examples. Often several stages of sifting are used to improve the separation. An interesting application of size separation is used in the purification of uranium. The gas diffusion method involves passing gaseous uranium through a series of filters. The larger U-238 atoms pass through the filters at a slower rate than the lighter U-2 35 atoms. The U-2 35 may be collected in an enriched form after many passes through the filters. The original mixture of isotopes may be separated into purified samples of the lighter and heavier forms.

V. Specific Properties of Materials: Some components of mixtures have special properties which allow separation of the mixture. For example, iron is magnetic and may be separated from a mixture by using a magnetic field. Some materials in an aqueous solution may be separated by their ability to pass through a semi-permeable membrane (actually a form of size separation). The charge on a molecule, a protein for example, can be used as a method of separation. This property is utilized in the various forms of chromatography and electrophoresis.

Use of the Kit in the Classroom

The kit is designed to be used by students enrolled in introductory physical science classes at either the junior high or high school levels. It is best utilized in conjunction with basic coverage of atoms, compounds, elements, and mixtures. The main focus of these discussions should be the importance of the chemical bonds in determining chemical behavior. The objectives of the kit are:

1. The student will carry out the separation of two component mixtures using five different separation techniques: (1) magnetic separation (2) size separation (3) flotation (4) solubility behavior and (5) melting/recrystallization. The student should be able to summarize the theory behind each technique.

2. The student will observe the difference between a mixture and a compound formed from the components of a mixture. The student will observe that the compound cannot be separated using any of the means described for the separation of mixtures. This feature should be related to the formation of a chemical bond during a chemical reaction.

3. The student will then apply the techniques to the separation of an unknown mixture.

Preparing the Materials

In addition to the materials provided in the kit, test tubes, Bunsen burners, test tube clamps, and a test tube rack are also needed.

Guide to the Student Materials

The introductory material is almost identical to the Background Information in the teacher's guide. It focuses the students' attention on the differences between compounds and mixtures, and gives an overview of separation techniques. Have the students spend some time trying to identify the various materials as mixtures or compounds, based on their homogeneity. The format of the student activities involves a step by step approach on the part of the student. The student is given samples of three different mixtures. *Mixture A* is composed of polystyrene and sulfur, *Mixture B* contains sulfur and iron filings, and *Mixture C* contains salt and stearic acid.

The label does not name the components of the mixture. You may want to tell the students what the mixtures are, either before or after the activities are completed. The students do not need to know what the mixtures are to benefit from the exercise. Knowing what the materials are may focus the student's attention on the substances themselves, and away from the techniques of separation.

1. The students are asked to examine their mixture, and give any evidence of the mixture containing more than one material.

2. The magnetic separation should be done first. This is the easiest test to perform. It will separate the iron filings from the sulfur mixture, but will not have any effect on the other mixtures.

3. The technique for size separation should be tried next. The sieve will separate the polystyrene from the sulfur, and the salt from the stearic acid. The sieve must be assembled by placing a square of screen over the mouth of a plastic cup and then snapping the plastic lid over this to hold it in place.

4. The next step involves separation by flotation. The sample mixture must be collected from the size separation technique. In order to demonstrate separation by flotation, the surface tension of the water must be reduced. Surface tension is the result of the water molecules' attraction to other water molecules. If the surface tension is not reduced, particles of the mixture will be caught on the surface of the water, even if they are denser than water. To reduce surface tension, add a drop of liquid detergent to the cup of water before conducting the flotation experiments.

   In the case of sulfur and polystyrene, the sulfur is denser than the water and will sink, while the polystyrene is less dense and will float. You may want to try this experiment without the use of liquid detergent to illustrate the effects of surface tension. Flotation is very important in the manufacture of iron and steel: impurities in the molten iron float to the surface of the liquid, and are removed as slag. Other methods that depend upon densities are centrifugation and gas diffusion techniques.

5. The mixture of salt and stearic acid may be separated by both the solubility and melting/ recrystallization techniques (phase change separation). Salt will dissolve in water, since water is polar. The liquid may be removed from this experiment and allowed to evaporate over night. This will show that the salt was actually dissolved in the water.

6. The organic material, stearic acid, has a lower melting point than salt and will melt first. Because the liquid stearic acid is nonpolar, it does not dissolve the salt. For melting/recrystallization, the molten stearic acid may be recovered by either pouring the liquid into a watch glass, or by tipping the test tube onto its side, and allowing the liquid to recrystallize on the side.

(Optional)

There is an optional reaction that shows the difference between compounds and mixtures that you might wish to demonstrate. The demonstration reacts the iron-sulfur mixture to form Fe_2S_3. This demonstration must be done in a fume hood. Place a spoonful of the iron/sulfur mixture in a crucible, and apply a Bunsen burner flame to the mixture. The mixture reacts strongly, producing the compound ferric sulfide. This material is magnetic, but cannot be separated into distinct components. This reaction description is also in the "Topics for Further Discussion" section, leading into a discussion of bond types.

ANALYSIS OF SIMPLE MIXTURES #1300 Student Instructions (Annotated)

Introduction

In the study of chemistry, a distinction is made between compounds and mixtures, each being composed of molecules. A compound consists of molecules joined together through chemical bonding. A bond is the "glue" that holds the compound together. Compounds do not have the same physical properties as their original components. Water, for example, is a compound composed of two molecules of hydrogen and one of oxygen, both of which are gases. When these molecules are joined under the appropriate conditions, a chemical bond is formed, "gluing" the two molecules together. The result of this bonding is the formation of water, a liquid. Mixtures are not "glued" together by chemical bonds. If any chemical bonds do exist, they are very weak and are easily broken at room temperature by the random motion of each molecule. Mixtures are much more easily separated into their original components than compounds. An example of a mixture is a mix of salt and pepper. When this salt and pepper mixture is placed in water, the salt will dissolve, leaving the pepper behind. The mixture is now separated.

A compound can be described as homogenous, since it contains the same material throughout; water contains many molecules of water. A mixture, on the other hand, is heterogenous, since it contains different molecules; the salt and pepper mix containing both molecules of salt and of pepper. It is sometimes difficult to see the heterogenous nature of a mixture. For example, air is a mixture, containing many different substances, yet it appears homogenous. Other mixtures, such as granite, consist of materials that are clearly distinguishable from each other.

To distinguish mixtures from compounds, one must try to separate the material into its components. Mixtures are more easily resolved into separate material than are compounds. Simply mixing these materials together again will regenerate the properties of the original mixture. Compounds, however, are very hard to separate, since they cannot be broken down without breaking the "glue" of the chemical bonds. Once the bonds have been broken, they must be re-formed to produce the original material. A compound cannot be re-formed by simply mixing the components together.

Here are some of the physical characteristics that can be used to separate mixtures:

Density: Objects that weigh different amounts can be separated through techniques like *flotation*. When the mixture is placed in a liquid that does not dissolve either component, one component may float and the other may sink.

Solubility Properties: A mixture may be placed in a liquid which will dissolve one of the components. An example of this process is the separation of a mixture of grease, sugar, and clothing (better known as dirty laundry). Water will dissolve sugar, but not grease or clothing. Detergent and water will dissolve grease. Neither will dissolve clothing. Adding both these solvents will result in clean clothing.

Phase Change Separation: Different materials melt and boil at different temperatures. Mixtures can be separated by cooling or heating the components until one condenses, melts, or boils.

Size Separation: If the materials in the mixture are particles of different sizes, then the mixture may be separated by using techniques related to size. *Sifting* and *filtering* are two examples.

Specific Properties of the Materials: Some components of mixtures have special properties which allow for separation. For example, iron is magnetic and may be separated form a mixture using a magnetic field.

DATA TABLE

Property	Mixture A	Mixture B	Mixture C
Magnetic	No Reaction.	Iron is attracted by the magnet, sulfur is not.	No Reaction.
Size	Polystyrene stays in the cup, sulfur goes through.	Both pass through the cup.	Both pass through the cup.
Flotation	Polystyrene floats and sulfur sinks.	Both sink.	Salt dissolves and sinks, stearic acid floats.
Solubility	No reaction.	No reaction.	Salt dissolves and can be recrystallized.
Melting	Sulfur melts, polystyrene does not.	Sulfur melts, iron does not.	Stearic acid melts then recrystallizes.

Topics for Further Discussion:

After completing the initial activities, you may want to consider some of the following topics:

1. Discuss the economic importance of such separation techniques as melting/recrystallization, flotation, solubility etc. Metallurgy, industry, agriculture, etc. all depend on an understanding of what the various separation techniques are capable of and what the limitations might be. Have the students write to various firms to gather specific information, or if possible arrange plant tours.

2. Combine the sulfur/iron (Mixture B) with the salt/stearic acid (Mixture C) mixture, and have the students separate this mixture into its four components. Other mixtures which are interesting, are vegetable oil and sugar (solubility) salt and sugar (sugar has a low melting point compared to salt).

3. Discuss the formation of chemical bonds and relate the stability of chemical bonds to the stability of compounds. The final section of the student materials lists an optional activity involving the sulfur/iron mixture. This demonstration must be done in a fume hood. Place a spoonful of the mixture in a crucible, and apply a Bunsen burner flame to the mixture. The mixture reacts strongly, producing the compound ferric sulfide, Fe_2S_3. This material is magnetic, but cannot be separated into distinct components. Point out the differences between compounds and mixtures, and the relationship of properties to the chemical bonds within a substance. With more advanced groups, you may develop a discussion of bond types, and the role of electrons in the formation of bonds.

Procedures:

Locate the three jars of mixtures labeled A, B, and C.

1. In a paper cup, place 1 1/2 spoonfuls of a sample mixture. Examine the mixture. Is there any evidence that the mixture contains more than one type of material? Note which sample you have taken; sample mixture A, B, or C. Run through all of the experimental steps using the same mixture.

   (In Mixture A, the students may be able to see the difference between the sulfur and polystyrene, The iron and sulfur in mixture B are also distinguishable. Mixture C may appear uniform.)

2. Place a magnet on the outside of the paper cup, move the magnet up and down on the side of the cup. If there is any ferric (containing iron) material in the sample, it will be attracted to the magnet. Record your result on the data table.

3. Place your sample in the plastic cup, secure the screen across the top with a plastic lid. Holding the cup over a piece of white paper, turn the cup upside down, and shake the sample. If all the material is of the same size, it will either fall through or be held back. If the material is of different sizes, they will separate. Record your results on the data table.

4. Pour your sample back into the plastic cup. Fill a styrofoam cup 2/3 full with water. Add 1 drop of soap or detergent to the water to make sure the flotation is not due to the surface tension of the water. Place 1/2 spoonful of the mixture into the water, and stir. Does any of the mixture float? Sink? Record your results on the data table.

5. Put another 1/2 spoonful of the sample mixture into a test tube. Fill the test tube 2/3 full of water, put the stopper in, and shake it well. Observe if any of the mixture has dissolved. (This is called going into solution). Pour a small amount of the liquid into the watch glass. Allow the liquid to evaporate. The process can be quickened by placing the watch glass in a window, or under a bright light. Record your results on the data table.

6. In your second test tube, put another 1/2 spoonful of your sample mixture. This time, leave the stopper out. Heat the mixture over the Bunsen burner. Keep the tube moving over the flame, and keep the open end pointing away from yourself and others. When the mixture starts to bubble remove it from the heat. Slowly tip the tube, do not invert completely. Lay the tube on its side. The melted part will collect on the side, and the solid will remain on the bottom. Record your results on the data table.

7. With a damp towel, wipe out the plastic cup and sieve screen. Empty the contents of the styrofoam cup into the proper receptacle, and rinse out the cup. Clean and rinse the test tube from the solubility experiment (5). Obtain another sample and run the same sequence of experimental steps. Information obtained from previous experiments may allow you to omit certain steps.

   How can you tell if a mixture has been separated?

   (If each of the parts obtained cannot be separated further, then they are assumed to be pure. Encourage the students to determine tests for a pure substance.)

Questions for Discussion

1. Some mixtures appear to be a single substance, yet are actually mixtures. Such a substance is described as being homogenous. Think of some homogenous materials that are really mixtures. How could you separate them?

   (Salad dressing contains both oil and vinegar, which will separate if left to stand. Paint contains both pigment and solvent. It can be separated by settling, or by evaporation of the solvent, as when the paint dries. Blood contains both cells and plasma, but these may be separated through centrifugation. Milk contains both fat and water. If left for long periods of time, it will begin to separate. Sea water contains salt, but this may be separated by evaporation of the water. Butter contains fat and protein, but may be separated by melting.)

2. Using your text, or a reference book such as encyclopedia, find out what separation techniques are used to manufacture iron, gold, gasoline, and other materials.

   (Iron sinks to the bottom of a furnace while slag floats to the top and is skimmed off Gold is dissolved in mercury, the is recrystallized from the mercury. Gasoline and other petroleum products are all separated through differential vaporization. Other examples are: grading of fruits and vegetables based on the size separation, and the production of alcohol through distillation.)

3. Your instructor may show you the reaction between the two parts of mixture B. The mixture consists of iron and sulfur. These two materials react to form a compound. Study the product of the reaction which your teacher shows you the describe the difference between a mixture and compound.

   (The Fe_2S_3 is a compound which cannot be separated into components. It will still be magnetic, since it contains iron. A mixture has components which may be separated without breaking chemical bonds. Components of the compound are held together by bonds.)

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3. Place your sample in the plastic cup, secure the screen across the top with a plastic lid. Holding the cup over a piece of white paper, turn the cup upside down, and shake the sample. If all the material is of the same size, it will either fall through or be held back. If the material is of different sizes, they will separate. Record your results on the data table.

4. Pour your sample back into the plastic cup. Fill a styrofoam cup 2/3 full with water. Add 1 drop of soap or detergent to the water to make sure the flotation is not due to the surface tension of the water. Place 1/2 spoonful of the mixture into the water, and stir. Does any of the mixture float? Sink? Record your results on the data table.

5. Put another 1/2 spoonful of the sample mixture into a test tube. Fill the test tube 2/3 full of water, put the stopper in, and shake it well. Observe if any of the mixture has dissolved. (This is called going into solution). Pour a small amount of the liquid into the watch glass. Allow the liquid to evaporate. The process can be quickened by placing the watch glass in a window, or under a bright light. Record your results on the data table.

6. In your second test tube, put another 1/2 spoonful of your sample mixture. This time, leave the stopper out. Heat the mixture over the Bunsen burner. Keep the tube moving over the flame, and keep the open end pointing away from yourself and others. When the mixture starts to bubble remove it from the heat. Slowly tip the tube, do not invert completely. Lay the tube on its side. The melted part will collect on the side, and the solid will remain on the bottom. Record your results on the data table.

7. With a damp towel, wipe out the plastic cup and sieve screen. Empty the contents of the styrofoam cup into the proper receptacle, and rinse out the cup. Clean and rinse the test tube from the solubility experiment (5). Obtain another sample and run the same sequence of experimental steps. Information obtained from previous experiments may allow you to omit certain steps.

   How can you tell if a mixture has been separated?

Questions for Discussion

1. Some mixtures appear to be a single substance, yet are actually mixtures. Such a substance is described as being homogenous. Think of some homogenous materials that are really mixtures. How could you separate them?

2. Using your text, or a reference book such as encyclopedia, find out what separation techniques are used to manufacture iron, gold, gasoline, and other materials.

3. Your instructor may show you the reaction between the two parts of mixture B. The mixture consists of iron and sulfur. These two materials react to form a compound. Study the product of the reaction which your teacher shows you, then describe the difference between a mixture and a compound.

SAFETY INSTRUCTIONS: IMPORTANT

NOTICE TO TEACHERS REGARDING LABORATORY REAGENTS

Perhaps the best general rule regarding the safe handling of laboratory chemicals is to treat all of them as being potentially dangerous. This means that none of them should be taken internally, and that any external contact should be washed thoroughly. In fact, most of the chemicals provided in The Science Source kits are diluted enough that they are not hazardous. The following lists indicate appropriate antidotes for the hazardous chemicals. Check this list for the chemicals provided in the kit:

I. **Concentrated Acids & Bases** - **Do not** induce vomiting, dilute with water, then milk or egg white, call a physician immediately.

1. 25 % Acetic Acid
2. 3M Hydrochloric Acid
3. Concentrated Sulfuric Acid

II **Dilute Acids & Bases** - **Dilute** with water, then milk.

1. 1 M, 0.5M, 0.1 M Hydrochloric Acid
2. Oxalic Acid
3. Sodium Hydroxide
4. Ammonium Hydroxide

III **Miscellaneous Chemicals** - Dilute immediately with water. Induce vomiting with warm salt water, or warm baking soda solution.

1. Ammonium Chloride
2. Ammonium Oxalate
3. Barium Chloride
4. Biuret Reagent
5. Bromthymol Blue
6. Calcium Chloride
7. Ethanol (Denatured Alcohol)
8. Ferric Ammonium Sulfate
9. Hydrogen Peroxide
10. Janus Green B
11. Lead Nitrate
12. Lugol's Solution
13. Magnesium Reagent (Titan Yellow, Alcohol)
14. Mercuric Nitrate
15. Methylene Blue
16. Ninhydrin
17. Phosphorus Reagent (Ammonium Molybdate, Nitric Acid)
18. Potassium Ferricyanide
19. Potassium Permanganate
20. Silver Nitrate
21. Sodium Carbonate
22. Sodium Thiosulfate
23. Sudan IV

IV. **Organic Solvents** - **Do not** induce vomiting. Dilute with water and milk. Call a physician immediately.

Isopropyl Alcohol