Scope, Sequence & Coordination

A National Curriculum Development and Evaluation Project for High School Science Education

A Project of the National Science Teachers Association

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Scope, Sequence & Coordination

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** Not part of the NSF-funded SS&C project.

National Science Education Standard—Physical Science

Structure and Properties of matter0

Carbon atoms can bond to one another in chains, rings, and branching networks to form a variety of structures, including synthetic polymers, oils, and the large molecules essential to life.

Teacher Materials

Learning Sequence Item:

965

Properties of Useful Carbon Compounds

March 1996

Adapted by: Ruth Mann, Jessie Jones and Dorothy Gabel

Hydrocarbons, Polymers, and Organic Macromolecules. Students should observe simple organic compounds and name and write formulas for them. It is important that experience precede terminology, and this kind of experience and naming, even without other levels of understanding, is very important. They should investigate the properties of (and/or synthesize when relatively simple and safe) carbon compounds useful to humans, such as dyes, medicinals, detergents, plastics, perfumes, fabrics, food, and fuels. They should investigate the origin of these compounds (coal, petroleum, natural gas, plants, and animals). (*Chemistry, A Framework for High School Science Education, p. 62.*)

Contents

This micro-unit was adapted by **Ruth Mann** (Northside H.S., Pinetown, N.C.), **Jessie Jones** (Rocky Mount, N.C.), and **Dorothy Gabel** (Indiana University, Bloomington)

965

Learning Sequence

Hydrocarbons, Polymers, and Organic Macromolecules. Students should observe simple organic compounds and name and write formulas for them. It is important that experience precede terminology, and this kind of experience and naming, even without other levels of understanding, is very important. They should investigate the properties of (and/or synthesize when relatively simple and safe) carbon compounds useful to humans, such as dyes, medicinals, detergents, plastics, perfumes, fabrics, food, and fuels. They should investigate the origin of these compounds (coal, petroleum, natural gas, plants, and animals). (*Chemistry, A Framework for High School Science Education, p. 62.*)

Science as Inquiry	Science and Technology	Science in Personal and Social Perspectives	History and Nature of Science
Family Characteristics **Activity 1**	From Wood to Paper **Activity 5**	Sugar in Beverages **Activity 8**	Commercial Alkanes **Reading 3**
Variations in Structures **Activity 2**	Color It Lavender **Activity 6**	Extracting Caffeine from a Beverage **Activity 9**	
Identifying Materials—Solids **Activity 3**	Painting a Picture? Use Milk! **Activity 7**	Carbon Compound **Assessment 3**	
What Is the Aroma? **Activity 4**	The Blue Jeans Story **Activity 10**	Hydrogen + Natural Gas = Hythane **Reading 1**	
Carbon Compounds **Assessment 1**	Plastics **Assessment 4**	Alcohol in Your Tank **Reading 2**	
Plastics **Assessment 2**	Natural Dyes **Reading 4**	Lipstick **Reading 6**	
	Tyvek **Reading 5**		

Suggested Sequence of Events

Event #1

Lab Activity

1. Family Characteristics (50 minutes)

Event #2

Lab Activity

2. Variations in Structures (50 minutes)

Event #3

Lab Activity

3. Identifying Materials–Solids (45 minutes)

Event #4

Lab Activity

4. What Is the Aroma? (30 minutes)

Event #5

Lab Activity

5. From Wood to Paper (60 minutes)

Alternative or additional experiments:

6. Color It Lavender (20 minutes)
7. Painting a Picture? Use Milk (50 minutes)
8. Sugar in Beverages (45 minutes)
9. Extracting Caffeine from a Beverage (30 minutes)

Event #6

Lab Activity

10. The Blue Jeans Story (30 minutes)

Event #7

Readings from Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives, and History and Nature of Science

Reading 1 Hydrogen + Natural Gas = Hythane
Reading 2 Alcohol in Your Tank
Reading 3 Commercial Alkanes
Reading 4 Natural Dyes
Reading 5 Tyvek
Reading 6 Lipstick

Readings can be found in the student version of this publication.

Assessment items are at the back of this volume.

Assessment Recommendations

This teacher materials packet contains a few items suggested for classroom assessment. Often, three types of items are included. Some have been tested and reviewed, but not all.

1. Multiple choice questions accompanied by short essays, called justification, that allow teachers to find out if students really understand their selections on the multiple choice.

2. Open-ended questions asking for essay responses.

3. Suggestions for performance tasks, usually including laboratory work, questions to be answered, data to be graphed and processed, and inferences to be made. Some tasks include proposals for student design of such tasks. These may sometimes closely resemble a good laboratory task, since the best types of laboratories are assessing student skills and performance at all times. Special assessment tasks will not be needed if measures such as questions, tabulations, graphs, calculations, etc., are incorporated into regular lab activities.

Teachers are encouraged to make changes in these items to suit their own classroom situations and to develop further items of their own, hopefully finding inspiration in the models we have provided. We hope you may consider adding your best items to our pool. We also will be very pleased to hear of proposed revisions to our items when you think they are needed.

Science as Inquiry

Family Characteristics

How do compounds in the simplest organic family, the alkanes, resemble one another?

Overview:

Students examine the properties of some alkanes, write formulas representing family members, and construct molecular models.

Materials:

Per class:
balloon filled with methane, suspended using thread
matches
meter stick with candle attached

Per lab group:
set of ball and stick models (other types such as Styrofoam™ balls and toothpicks could be used but are not as advantageous because the ball and stick models have holes for indicating bonding)
butane lighter
mL gasoline
mL mineral oil
1 g paraffin
burner
ring stand and ring
metal can lid covered with aluminum foil
matches

Procedure:

Fill a small balloon with methane from a gas jet (if the balloon is stretched overnight by filling it with air and tying it, it will be much easier to fill during class.) Ignite it by bringing a lighted candle attached to a meter stick next to the balloon. A class discussion of the products of combustion should follow this demonstration.

Write the word equation and a balanced formula equation on the chalkboard. Students at this point should not be expected to balance chemical equations. After explaining that this is the simplest member of the alkane family, have students construct a molecular model of the compound and describe the physical and chemical characteristics. They then set up the ring stand and ring and place the can lid covered with aluminum foil on the ring. A burner is placed beneath the iron ring. They place one drop of each liquid near the circumference and a piece of paraffin about the size of a match head in the center.

Gently heating the lid, they should note the melting behavior of the solid and the point at which each burns.

Give students a table (see following page) that is partly completed on the first 10 alkanes and ask them to complete it. (Only straight-chain hydrocarbons are considered in this activity. The next activity examines isomers.)

Students then examine the characteristics of other members of the alkane family (provided in the questions) and reach conclusions about the relative weights of the molecules and the melting and boiling points.

Background:

The simplest group of organic chemicals is that of the hydrocarbons, which contain only hydrogen and carbon. Because students have not yet been introduced to chemical bonding, only saturated straight-chain hydrocarbons will be considered in this activity. This family or series is called the paraffin family from the Latin *parum affinis*, meaning “little affinity,” because the compounds are unaffected by many other chemicals. Each element in the series ends in "ane."

As the molecular weight of each compound in the series increases, so does the compound's density and melting and boiling points. The compounds in the series resemble one another in their physical and chemical properties. All react with oxygen to produce carbon dioxide and water.

Adapted from American Chemical Society, *ChemCom*, 2nd ed., 1993 Adapted from American Chemical Society, *ChemCom*, 2nd ed., 1993

Alkane Series

# of C	# of H	Name	Use	Empirical formula	Molecular formula	Structural formula	Melting point (°C)	Boiling point (°C)	Result of burning
1	4	methane	fuel	CH_4	CH_4	H HCH H	-184	-161	water and carbon dioxide
2	6	ethane	fuel	C_2H_6	CH_3		-171	-88	
3	8	propane	fuel				-187	-42	
4		butane	fuel				-135	-0.6	
5		pentane					-131	36	
6		hexane					-94	69	
7		heptane					-90	98	
8		octane					-56	126	
9		nonane					-54	151	
10		decane					-30	174	
12-20		mineral oil							
above 20		paraffin							

Science as Inquiry

Variations in Structures

How do alkanes with the same molecular formula differ from one another?

Overview:

Students note the differences in the physical and chemical properties of the isomers of some alkanes, construct molecular models, and write structural formulas for isomers.

Materials:

Per lab group:

1 set of ball and stick models (other types such as Styrofoam™ balls and toothpicks could be used but are not as advantageous because the ball and stick models have holes for indicating bonding)

Procedure:

Students will construct ball and stick models of the first eight alkanes and draw the structural formulas. The table on the following page will be useful in helping them organize their data.

Background:

Molecules having identical molecular formulas but different structural formulas are called isomers. Each isomer is a different chemical species and hence has a different set of physical properties, such as boiling points and melting points. For example, the boiling points of the three isomers of pentane vary from 36.1 for the five-carbon straight chain to 27.8 for the four-carbon chain and 9.5 for the three-carbon chain. As the isomers have more and more branched chains, their boiling points tend to decrease.

Because the molecules have the same number of hydrogen and carbon atoms, their densities are very similar, but there are slight differences due to the arrangements of the atoms in the molecules. Straight and branched chained isomers also have the same heat of combustion. However, the rate at which the various isomers burn varies considerably depending on the compactness of the molecule. For example, the straight-chain octane molecule burns exceedingly fast because all of the carbon and hydrogen atoms can be more readily bombarded with oxygen than those branched-chain molecules containing carbon-carbon bonds. Straight-chain octane makes a poor engine fuel because the rapid burning of the fuel causes the engine to “knock.”

Scientists today can modify alkane molecules through cracking and other chemical reactions to create fuels with appropriate mixes of molecules that promote steady and more uniform burning.

Alkane Series

# of C	# of H	Molecular formula	No. of isomers	Isomer 1	Isomer 2	Isomer 3	Isomer 4	Isomer 5	Isomer 6
1	4	CH_4	1	H HCH H					
2	6	C_2H_6	1	HH HC-CH HH					
3	8	propane	1						
4		butane	2						
5		pentane	3						
6		hexane							
7		heptane							
8		octane							

Science as Inquiry

Identifying Materials–Solids

What tests can be performed to distinguish one material from another?

Overview:

Students test and distinguish various types of solids. These include metals, ceramics, glasses, plastics, and fibers.

Materials:

Per group:

1 Bunsen burner
1 cloth
1 hammer
1 goggles
6.0 M hydrochloric acid solution in dropper bottles
1 magnifying glass or low-power microscope
1 multimeter or conductivity apparatus
samples of metals. ceramics, glasses, plastics, and fibers
1 tongs, insulated

Procedures:

Have students form three-member lab groups to investigate the properties of samples of metal, ceramic, glass, plastic, and fiber. After performing each test, observations should be recorded in a table similar to Table 2. Students use Table 1 below to aid in drawing conclusion.

Table 1: Physical and Chemical Properties

Type of Material	Typical Properties
Metals	• Malleable, can be bent • Conduct heat and electricity well • May react with air, water, and acids
Ceramics	• Brittle • Strong when compressed, weak when stretched • Chemically unreactive
Glasses	• As for ceramics but also transparent
Plastics	• Flexible • Easily melted and molded • May burn when heated in air
Fibers	• Form long hairlike strands • Flexible • May burn when heated in air

Students should follow the procedure outlined on the student sheet. *Warn them to use goggles for the activity*. Have them make a data table to record their observations for each test for each of the five solids.

Students first place a few drops of 6.0 M hydrochloric acid (HCl) solution on each sample and examine each with a magnifying glass or low-power microscope. Caution them to follow safety procedures for using acids. They should try to bend each sample at three points.

Next they use an insulated pair of tongs to hold each sample in the Bunsen burner flame to observe and record the high-temperature behavior of the material. Caution them to perform the experiment in a hood or well-ventilated area. Next, measure the electrical resistance using a multimeter or a conductivity apparatus to determine the electrical conductivity of each sample. Finally, have students wrap samples in a cloth and, gently striking each with a hammer, try to cause a fracture and observe whether the sample is brittle and opaque or brittle and transparent. A sample data table is shown below.

Data and Observations

	Samples				
Table	#1	#2	#3	#4	#5
Reacts with acid					
Malleable, can be bent					
Burns when heated in air					
Conducts electricity well					
Brittle					
Transparent					

Each group should be given a pack consisting of five different samples numbered 1, 2, 3, 4, and 5. The samples should include a metal, a ceramic, a piece of glass, a plastic, and a fiber, and each should be painted black so that students cannot tell its normal appearance.

Background:

The properties given include both physical and chemical properties. Both of these are important when deciding which materials to use for a job. Some materials may have the same or similar properties, but there is always a distinguishing characteristic.

Table 2 shows typical results from the tests used in this lab.

Table 2: Data and Observations					
Test	Metals	Ceramics	Glass	Plastics	Fibers
Reacts with acid	Yes	No	No	No	Yes
Malleable—can be bent	Yes	No	No	Yes	Yes
Burns when heated in air	No	No	No	Yes	Yes
Conducts electricity well	Yes	No	No	No	No
Brittle	No	Yes	No	No	No
Transparent	No	No	Yes	No	No

Suggested Answers to Student Questions:

1. glass and plastic
2, form long, strong hairlike strands
3. student answer
4. student answer
5. metal

Further Variations:

Students could make a survey of materials found in the home and list their uses. They could determine what physical and chemical properties make each material suitable for these uses. Also, they could find the cost of each material and determine, if not for cost, whether another better material might have been used. Additionally, students could look for composite materials in the home and try to determine what separate materials make up each composite and why these materials are used.

Further, students could find out about special materials, such as the ceramics used in car engines, kevlar, teflon, heat-resistant materials that are used in fire blankets, and superconducting materials.

Adapted from Holman, J., *The Material World*, Canada: Nelson, 1991.

Science as Inquiry

What Is the Aroma?

How can an ester with a pleasing aroma be produced?

Overview:

Students prepare esters having familiar odors.

Materials:

Per group:

5 dropper bottles, Beral pipettes, or containers labeled with the acids
4 dropper bottles or Beral pipettes labeled with the alcohols
7 test tubes, small
1 test tube rack
1 test tube holder
7 stirring rods
14 pieces of filter paper or paper towels
1 hot water bath
boiling chips
2 spatulas

Per class:

concentrated sulfuric acid in a dropping bottle for use by the teacher

Procedure:

Warn students to use goggles and aprons.

Students place one drop of the acid and one drop of the alcohol on opposite sides of a piece of filter paper. They then describe the odor of the acid and alcohol. They should add the indicated number of drops of the alcohol and the indicated number of drops of the acid to the test tube and swirl gently to mix the contents.

The **instructor** then adds one drop of concentrated sulfuric acid to the test tube. Students place the test tube in a boiling water bath for one minute after adding a boiling chip to the test tube. They transfer a drop of the reaction mixture to a clean sheet of filter paper and describe the odor of the new compound.

This experiment involves substances that may be harmful if they are misused or if the procedures described are not followed. Do not use or combine any substance or materials not specifically called for in the directions.

The **instructor** must add the drops of sulfuric acid (used as a catalyst) because concentrated sulfuric acid can react so vigorously with organic materials that explosions can occur. Use small amounts only. ***Caution: All acids used in this experiment are extremely corrosive***. Demonstrate the technique for wafting vapors toward the nose to describe odor. ***Students must wear goggles and aprons***. They should read labels on all bottles carefully. They must use the test tube holder to place the test tube in the boiling water bath. If the reaction mixture begins to boil too quickly, they should remove it from the water bath for a few seconds and slowly return it. Water should not get into the test tube during heating because it is a product of esterfication and would tend to decrease the amount of ester produced. Use a stirring rod to transfer a drop of the reaction mixture to a clean sheet of filter paper.

Students must not attempt to taste esters. The quantity of ester described in the procedure may safely be rinsed down the drain.

Before class, prepare dropper bottles, Beral pipettes, or containers with the acids and alcohols from Table 1 at each lab station. Label each with the word "acid" or "alcohol" and the appropriate number of drops to be used in the reaction.

Table 1. Acid and Alcohol Identification

Alcohol		**Acid**		**Ester**	**Odor**
iso-amyl alcohol 20 drops	+	acetic acid 10 drops	♦	iso-amyl acetate	banana
ethyl alcohol 20 drops	+	acetic acid 10 drops	♦	ethyl acetate	fingernail polish remover
methyl alcohol 15 drops	+	salicylic acid 1 scoop (0.1 g)	♦	methyl salicylate	wintergreen
ethyl alcohol 8 drops	+	butyric acid 10 drops	♦	ethyl butyrate	pineapple
benzyl alcohol 12 drops	+	butyric acid 10 drops	♦	benzyl butyrate	cherry
ethyl alcohol 15 drops	+	propanoic acid 20 drops	♦	ethyl propionate	rum
ethyl alcohol 20 drops	+	benzoic acid 1 scoop (0.4 g)	♦	ethyl benzoate	fruity

Background:

The odors produced will resemble those shown in Table 1 above. Natural flavorings are frequently esters and they can be produced in the laboratory.

Esters are produced when an organic acid reacts with an alcohol. The word equation that would suitable for the ninth grade level is

alcohol + acid = ester + water.

An example of one of the reactions given in the activity is

iso-amyl alcohol	+	acetic acid	=	iso-amyl acetate	+	water
$(CH_3)_2CHCH_2CH_2OH$	+	CH_3COOH	=	$(CH_3)_2CHCH_2CH_2OOCCH_3$	+	H_2O

Further Variation:

Have each student group prepare a different ester using data in Table 1 and then trade test tubes in order to detect odors of all the esters.

Adapted from Kochansky, Mary, *Petrochemical*. American Chemical Society, 1991.

Teacher Sheet

Science and Technology

From Wood to Paper

How can cellulose be recovered from wood?

Overview:

Students remove cellulose from wood.

Materials:

Per group:

sawdust
100 mL sodium hydroxide (NaOH) solution, 6 M (240 g/liter solution)
100 mL sodium sulfide (Na_2S) solution, 3 M (234 g/liter solution)
200 mL laundry bleach
2 beakers, 100 and 300 mL
1 graduated cylinder, 100 mL
1 Bunsen burner
1 rustproof wire screen
1 glass stirring rod

Procedure:

Have students sift enough sawdust with a wire screen to fill a 100-mL beaker and then pour it into a 300-mL beaker. They add 100 mL of sodium hydroxide solution. In the hood, they add 25 mL of sodium sulfide solution and heat this mixture until it boils. They should boil gently for 15 minutes and then remove the beaker from the heat and let the wood pulp settle to the bottom.

After carefully pouring off the liquid, students fill the beaker with water, stir to mix, and let the pulp settle again. They then pour off the water layer. This process is repeated two or three times to remove the sodium hydroxide and sodium sulfide. They should then add 200 mL of laundry bleach and let the pulp soak in the bleach overnight. The next day, they should pour off the bleach and wash the pulp several times.

When removing lignin to recover the cellulose in the form of paper, observe all safety precautions. Wear goggles, gloves, and a face shield when handling sodium hydroxide solution. ***Avoid contact with sodium sulfide. It is toxic.***

Use fine wood particles. Do not use the particles that will not come through the screen. Notice the liquid that is formed. It contains resins, gums, lignin, and other soluble substances.

Background:

Paper is made from the polysaccharide cellulose found in wood. This polysaccharide consists of long chains of glucose molecules. Cellulose molecules form long fibers that are held together in the plant material by lignin, a large and complex polymer. Cellulose is held together in paper primarily by hydrogen bonds.

Further Variation:

Students could produce a really white product by soaking the pulp in 200 mL of laundry bleach over several nights. They also could produce a very thin sheet of paper (as in newspaper), and make a strong durable paper.

Adapted from Borgford, C.L. and Summerlin, L.R. *Chemical Activities*. Washington, D.C.: American Chemical Society, 1988.

alternative/extension activity for Event 5

Teacher Sheet

Science and Technology

Color It Lavender

How can a lavender paint pigment be prepared?

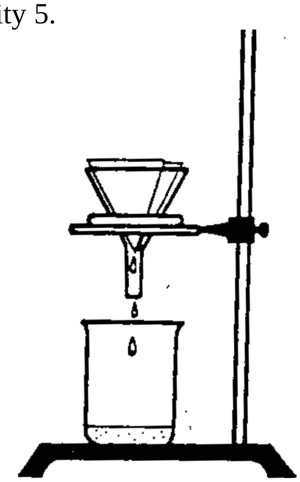
Materials:

Per group:

1 beaker, 250 mL
1 g cobalt chloride
1 filter paper
1 funnel
1 graduated cylinder (10 mL)
ring stand
sodium carbonate (1 g)
1 small test tube with stopper (20 mL)
1 stirring rod
3 watch glasses

Procedure:

Have students dissolve 0.2 g of cobalt chloride in a test tube containing 10 mL warm water. They then add 0.2 g of sodium carbonate, shake it thoroughly, and filter. They should discard the filtrate and save the precipitated pigment on several watch glasses. After the precipitate dries overnight, the pigment will be used to make paint in Activity 5.



The drying process can be hastened by spreading the precipitate on several watch glasses, making a thin “smear.” If the precipitate is thoroughly dry, it will scrape off the watch glass as a dry powder. Avoid touching the pigment with fingers.

Background:

$CoCl_2$ in its hydrated state is pink. When it reacts with sodium carbonate, it forms cobalt carbonate, which can be used as a pigment for paints.

$$Co2+ \text{ (aq)} + CO3^{2-} \text{ (aq)} \ \blacklozenge \ \underset{\text{pale purple}}{CaCO_3 \text{ (S)}}$$

Further Variations:

Students could prepare additional pigments, such as white, green, brown, blue, orange, and royal blue, and use them to make paint.

Adapted from Borgford, C.L. and Summerlin, L.R. *Chemical Activities*. Washington, D.C.: American Chemical Society, 1988.

alternative/extension activity for Event 5

Teacher Sheet

Science and Technology

Painting a Picture? Use Milk!

How can skim milk be used to paint a picture?

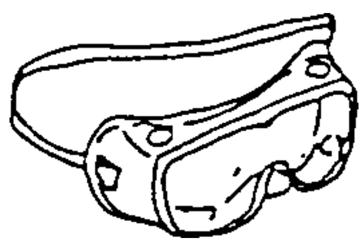
Overview:

Casein is separated from milk and used as a binder for pigments.

Materials:

Per group:

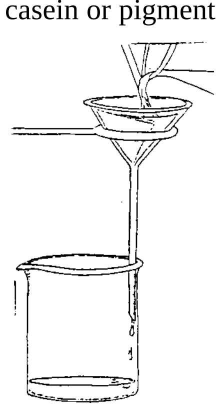
1 beaker, 250 mL
1 Bunsen burner
1 evaporating dish
1 filter paper
1 knife for chopping
1 mortar and pestle
skim milk (~ 200 mL)
1 stirring rod
vinegar (~ 20 mL)
1 wooden splint or spatula



Procedure:

Students heat 188 mL of skim milk until it begins to boil. They remove the beaker of hot milk and slowly, while stirring, add 10 mL of vinegar. They should let the milk stand for a few seconds. If the liquid is still cloudy, they should add a little more vinegar while stirring, continuing to add vinegar in this manner until the liquid is almost clear. They carefully decant the liquid from the beaker and remove water from the thick precipitate by wrapping it in a layer of filter paper and gently squeezing it. They then chop the casein into small pieces, dry them, and grind them into a fine powder with a mortar and pestle.

Have students place a small amount of casein (enough to cover a penny) in an evaporating dish. They add just enough water to make a thick paste and add about the same amount of lavender pigment that was prepared in the earlier lab exercise. Using the wooden splint, they mix the casein and the lavender pigment until the desired lavender color is obtained. More casein or pigment is added as needed. Finally, students paint a picture!



Background:
Casein, when separated from the milk, forms a binder for the lavender pigment. The binder keeps the pigment soft, allowing it to be spread on paper or canvas. The pigment is not dissolved in the binder but is suspended in it. The acid, vinegar, precipitates the casein from the solution in milk. Once formed, it dries. However, it can be kept moist by storing it in a plastic bag. This process is used commercially in preparing some waterproof artists' paints.

Further Variation:
Students may repeat the process by adding prepared pigments to about the same amount of casein. They can compare their paints to commercially available artists' paints and try them.

Adapted from Borgford, C.L. and Summerlin, L.R. *Chemical Activities*. Washington, D.C.: American Chemical Society, 1988.

alternative/extension activity for Event 5

Teacher Sheet

Science in Personal and
Social Perspectives

Sugar in Beverages

How can the presence of sugar in apple juice be determined?

Overview:

Students use Benedict's solution to test for sugar.

Materials:

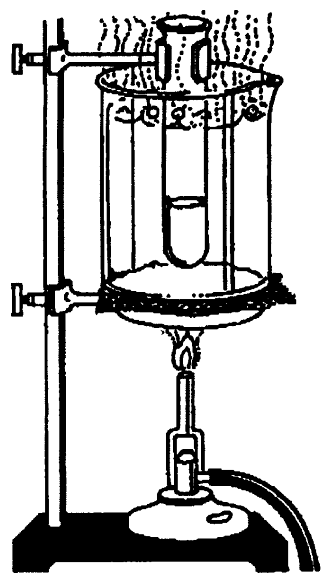
Per group:
1 beaker, 500 mL
1 Benedict’s reagent (2 cm^3)
1 Bunsen burner
hydrochloric acid, 2 cm3 (1 M HC1; dissolve 95 mL reagent HCl in 1000 mL of solution)
litmus paper, red
1 ring stand
sodium hydroxide, 2 cm^3 (1 M NaOH; 40 g /1000 mL solution)
1 test tube (20 mL)
1 utility clamp
1 wire gauze

Procedure:

Have students add 2.0 cm^3 of 1 M HC1 solution to 2.0 cm^3 of apple juice in a test tube. They heat this for five minutes in a boiling water bath and then add 2.0 cm^3 of 1 M NaOH solution. ***Caution: Acid and bases burn skin and eyes.***

Students then test with red litmus paper. If the paper remains red, they should add drops of 1 M NaOH solution until the paper turns blue. They add 2.0 cm^3 of Benedict’s reagent to the test tube and heat in the boiling water bath for 10 minutes.

When testing with red litmus, the color change should be double checked by using a second piece of red litmus paper.



Background:

Benedict’s reagent causes the color to change to reddish brown in the test tube. This indicates that the sugar has undergone hydrolysis to the smaller molecules of fructose and glucose. The Benedict's reagent can be purchased through chemical suppliers.

Further Variation:

Students could check the proportion of juice in a variety of juice liquids, such as grape drink (6% real grape juice), grape juice drink (containing 30% juice), “ade” (containing at least 15% juice), nectar (at least 50% juice), and juice (100% juice).

Adapted from *The Chemistry of Beverages*. Illinois: Flinn Scientific, 1989.

alternative/extension activity for Event 5

Teacher Sheet

Science in Personal and
Social Perspectives

Extracting Caffeine from a Beverage

Is there caffeine in tea?

Overview:

Students test beverages for the presence of caffeine.

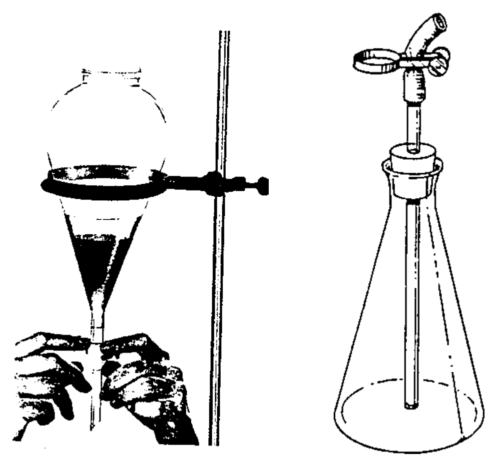
Materials

Per group:

ammonia (6 M NH3 (aq) (218 mL reagent/liter)
1 Bunsen burner
30 mL chloroform
1 evaporating dish
100-mL graduate cylinder
2 mL iodine test solution, in dropper bottle (1 g iodine + 2 g potassium iodide + water to 100 mL)
1 separatory funnel or conical flask tubing apparatus, 250 mL
2.5 mL 0.2 M sulfuric acid (11 mL/liter)
water, distilled
tea or coffee, 30 cm^3

Procedure:

Have students mix 30 cm^3 of tea, 30 cm^3 of chloroform, 1.5 cm^3 6 M NH_3 aq, and 1.5 cm^3 of distilled water in a separatory funnel and shake gently for 30 minutes. They should allow it to stand until the lower denser layer becomes clear and then drain off 20 cm^3 of the lower denser chloroform-caffeine solution into a labeled evaporating dish. They should allow the chloroform to evaporate overnight, or longer if necessary, in a fume hood.



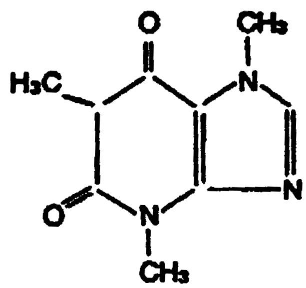
Caution: Chloroform is harmful if inhaled. Avoid breathing vapor, and avoid contact with eyes, skin, and clothing. After handling, wash thoroughly.

After evaporation occurs, students add 2.5 cm^3 of 0.2 M H_2SO_4 solution to the caffeine residue in the evaporating dish and stir until the residue is dissolved in the acid solution. They heat this solution very gently for 15 seconds, then cool it for five minutes. After adding 3–5 drops of iodine test solution, students will note that a red-brown precipitate forms, indicating the presence of caffeine.

If no separatory funnel is available, use the flask-tubing apparatus shown here, or shake the mixture in a stoppered bottle. Separate the liquids by pouring them into a regular funnel fitted with a short length of rubber tubing and a clamp. If coffee is used, better results may be gained by first extracting the oil. Have students label the evaporating dish with name, time, and date.

Background:

Caffeine is an organic compound with alkaline properties called an alkaloid. This class of compounds contains carbon, hydrogen, nitrogen, and usually oxygen, and the compounds are colorless and bitter. Another familiar alkaloid is nicotine. The formula for the anhydrous form of the compound is given below. Natural caffeine occurs as a monohydrate. The compound is a stimulant and is used as a drug by physicians. It is easily absorbed by the body. The molecules that enter the blood are altered by the body and may persist for a week.



In this activity, the caffeine dissolved in the water solution of the tea, cola, coffee, etc., dissolves in the chloroform for which it has a greater affinity. The chloroform is evaporated and the remaining product is tested with iodine solution.

Further Variation:

This lab may become quantitative by having students determine the percentage of caffeine in several popular beverages.

Adapted from *The Chemistry of Beverages*. Illinois: Flinn Scientific, 1989.

Science and Technology

The Blue Jeans Story

How can the oxidation-reduction of indigo dye be demonstrated?

Overview:

Students prepare indigo dye and use it to color a piece of fabric.

Materials:

Per group:

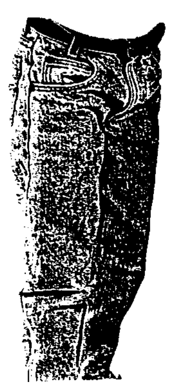
1 Bunsen burner
1 cloth, white cotton strip
1 forceps
1 graduated cylinder (25 mL)
15 g indigo, solid
15 g sodium hydroxide (NaOH)
.2 g sodium hydrosulfite ($Na_2S_2O_4$)
1 stirring rod
1 test tube
1 thermometer (100 °C)

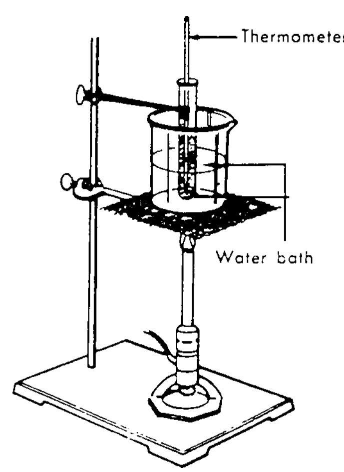
Procedure:

Have students place a test tube containing 15 cm^3 of solution that is 0.25% indigo and 0.25% sodium hydroxide in a beaker of water heated to 50 °C. When the mixture in the test tube is heated to 50 °C, they stir it well and add 0.2 g of sodium hydrosulfite ($Na_2S_2O_4$). They let this mixture stand about 30 minutes, keeping the temperature at 50 °C and stirring occasionally.

Students then dip a clean strip of white cotton cloth in the solution. They lift the strip out with forceps, blot off the excess liquid with a paper towel, and hang it in the air to dry.

The indigo-sodium hydroxide solution (Solution A) is prepared by dissolving 1.5 g of NaOH in 5.0 mL of water in a test tube, then adding 1.5 g of solid indigo. ***Use a face shield and gloves when handling concentrated bases***. While shaking the test tube, add 20 mL of water.

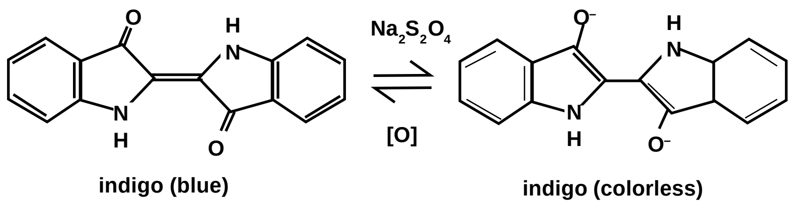




Background:

Indigo is blue and insoluble in water in its usual form. The blue indigo will change to yellow-green "indigo white" as the sodium hydrosulfite reduces it. The hydrosulfite is a chemical reducing agent. If the solution does not appear yellowish-green, add a few extra crystals of sodium hydrosulfite.

The reaction is:



As long as the cotton cloth is in the solution, it stays white. As the "indigo white" becomes oxidized by the oxygen in the air, it turns blue. If a deeper blue color is desired, repeat the dipping and pulling out several times. Indigo is a vat dye due to this process. The denim used to make blue jeans is often dyed with synthetic indigo. This insoluble blue pigment is permanently bound to the fabric. Therefore it is called a fast dye.

Further Variation:

This reaction has historical implications, because indigo is one of the oldest known dyes. Students may investigate dyeing as the ancients did by using juices from various berries, nuts, and roots.

Adapted from:

The Chemistry of Color. Illinois: Flinn Scientific, 1989.

Summerlin, L.R., Borgford, C., and Ealy J. *Chemical Demonstrations*, Volume 2. Washington, D.C.: American Chemical Society, 1988.

Science as Inquiry

Carbon Compounds

Item:
Which of the following compounds does not contain carbon?

A. plastics
B. motor oils
C. sugar
D. table salt

Justification:
Write the formula of your choice

Answer:
D.

Science as Inquiry

Plastics

Item:
Which property of plastic never varies?

A. melting point
B. texture
C. density
D. none of the above

Justification:
Write a statement that is true of all plastics.

Answer:

Science in Personal and
Social Perspectives

Carbon Compound

Item:
What carbon compound synthesized by humans has beneficial uses in your daily life? Describe ways in which it is useful.

Identify a carbon compound synthesized by humans that has caused environmental problems. Explain why.

Answer:

Science and Technology

Plastics

Item:
Today most calculators and computers are made of plastics. Think of all the things that exist today that are made of plastic. How has this enhanced scientific research?

Alternate:
How has plastic changed home life? Briefly discuss the advantages and disadvantages of switching to plastics.

Select one plastic item that used to be made of something else (e.g.., metal vs. plastic bucket).

Answer: