FISH GUT CHROMATOGRAPHY

AND OTHER CHEMISTRY ACTIVITES from HOLLINGS MARINE LABORATORY

LESSON PLANS

SEPTEMBER 29, 2007

Hollings Marine Laboratory
National Centers for Coastal Ocean Science
Ocean and Human Health Initiative
National Oceanic and Atmospheric Administration
331 Ft. Johnson Rd. Charleston, SC 29412
Phone 843.762.8824 www.hml.noaa.gov

During the summer of 2007, the NOAA Hollings Marine Laboratory (HML), in partnership with the South Carolina Sea Grant Consortium (SCSGC), enlisted Charleston area master teachers Connie Leverett, Denie Ravenel, Clarice Wenz and Norma Ashburn to work with HML scientists to produce chemistry curriculum activities based on real world environmental issues and measurements. On September 27, the two organizations hosted a workshop at HML for 25 area teachers to learn about chemistry research at HML and to practice the activities. Participating scientists from NOAA and the National Institutes of Standards and Technology (NIST) participated in the workshop. Teacher Connie Leverett is currently attending educator professional development conferences to present the activities.

HML is a partnership laboratory operated by NOAA that enables NOAA, NIST, College of Charleston, Medical University of South Carolina, and South Carolina Department of Natural Resources scientists to work together towards an interdisciplinary understanding of coastal ecosystem health (see: www.hml.noaa.gov). HML works cooperatively with the SCSGC (www.scseagrant.org) to transfer new science-based information to a variety of audiences.

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FISH GUT CHROMATOGRAPHY and WHAT YOU CAN'T SEE CAN HURT YOU

Video for Classroom Use

(on CD available in limited quantities from HML, contact hml.web@noaa.gov)

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LESSON ONE
Separation of Mixtures

DEVELOPED BY DENIE RAVENEL

FOCUS

When two or more substances that do not react chemically are combined together, the result is a mixture in which each component retains its individual identity and properties. The separation of the components of a mixture is a problem frequently encountered in chemistry. The basis of the separation is the fact that each component has a different set of physical and chemical properties.

GRADE LEVEL

Grades 9-12

SUBJECT AREA

Chemistry

FOCUS QUESTION(S)

- What methods can be used to separate two different substances that are mixed together?
- What physical properties of substances make it easy to separate them from each other?
- What is the difference between qualitative data and quantitative data?
- Could you separate sugar and table salt?
- What is a flow chart and what is its purpose?
- Do animals need flame-retardants in their eggs?

SOUTH CAROLINA CHEMISTRY STANDARDS

Standard C-6: The student will demonstrate an understanding of the nature and properties of various types of chemical solutions.

C-6.11 Use a variety of procedures for separating mixtures (including distillation, crystallization filtration, paper chromatography, and centrifuge.)

Qualitative Separation of Mixture Lab

Standard C-5: The student will demonstrate an understanding of the structure and behavior of the different phases of matter.

C-5.8 Analyze a product for purity by following the appropriate assay procedures.

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Quantitative Separation of Mixture Lab

Standard C-1: **The student will demonstrate an understanding of how scientific inquiry and technological design, including mathematical analysis, can be used appropriately to pose questions, seek answers, and develop solutions.**

Indicator covered depends on lab choice and reporting method.

C-1.1 Apply established rules for significant digits, both in reading a scientific instrument and in calculating a derived quantity from measurement.

C-1.2 Use appropriate laboratory apparatuses, technology, and techniques safely and accurately when conducting a scientific investigation.

C-1.3 Use scientific instruments to record measurement data in appropriate metric units that reflect the precision and accuracy of each particular instrument.

C-1.5 Organize and interpret the data from a controlled scientific investigation by using mathematics (including formulas, scientific notation, and dimensional analysis), graphs, models, and/or technology.

C-1.6 Evaluate the results of a scientific investigation in terms of whether they verify or refute the hypothesis and what the possible sources of error are.

C-1.8 Use appropriate safety procedures when conducting investigations.

APPROXIMATE TIME

2-3 periods

MATERIALS

Per Lab Group:

- Ammonium chloride
- Sodium chloride
- Silicon dioxide
- 400-600 mL beakers
- hot plate
- ring stand
- small iron ring
- funnel
- distilled water
- watch glass
- balance
- stirring rod

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- filter paper

BACKGROUND INFORMATION

See Pre-Lab

TEACHER TIPS

- The three solids are ammonium chloride (use between 0.2g and 0.5g because this takes the longest to remove), sodium chloride (use 2 – 5 g), and silicon dioxide (sand use between 2 and 8g). A total sample weight of 10 g works well.
- Ammonium chloride mimics sublimation. When heated ammonium chloride decomposes into ammonia ($NH_{3(g)}$) and hydrogen chloride ($HCl_{(g)}$). These products react to form the solid that can be collected and weighed. This collection mimics deposition.
- This lab can be done qualitatively, quantitatively, or as an exploration. All three solids can be recovered of desired.
- Students may be given the actual masses in the mixture to determine error and % error.

Understand: The components of mixtures are combined physically and can be physically separated or partitioned into the individual parts using techniques based on the physical properties of the components. The ratios of substances in a mixture may vary and can be quantified.

Know: The definitions and appropriate use of the following vocabulary: matter, mass, volume, properties, physical properties (melting/freezing point, solubility, phase/state, temperature, pressure, magnetic, volatile), phases, solid, liquid, gas, plasma, melting, freezing, boiling/vaporization, condensation, sublimation, deposition, filtration, re-crystallization, qualitative, quantitative, measure, SI/metric units, evidence, data, chromatography, distillation, decanting, solvent, solute, flow chart, separation, element, compound, mixture, residue, filtrate

- Physical properties describe the physical nature of a substance.
- Matter can exist in the solid, liquid, gaseous, or plasma phase.
- Phases and physical properties of matter contribute to their dispersal in the environment
- Phases of matter are a result of the motion and arrangement of the atoms or molecules that compose the substance. The phase in which material exists depends on the nature of the material, the temperature and the pressure.
- How to use a balance to determine mass.

- How to record and communicate the observations/data through graphs, tables, and words
- The fundamental metric units
- How to calculate percent composition by mass
- How to find/use library resources for science
- How to find/use other resources for science

Do:

- Qualitatively separate/partition a mixture of three white solids based on their physical properties. – Physical separation techniques lab – all levels – introduces the techniques
- Quantitatively separate/partition a mixture of three white solids based on their physical properties. – Physical separation techniques lab – uses the techniques to obtain numerical data that can be manipulated
- Determine the % composition of a material from mass data
- Design an experiment to separate a mixture, recover the parts, and determine the percent composition of the mixture – uses the skills above design and carry out an experiment to separate a mixture
- Report the results of the separation in a formal lab report.
- Use references to determine the physical properties of the three solids

Applications:

- Separation/partitioning of samples are necessary for testing, purification, and analysis.
- Sublimation is often harder to give examples for than the other phase changes. Sublimation occurs in dry ice, solid iodine, the freeze-drying process, frost-free freezers…Snow on the mountains out west is dry. It does not melt, but sublimes.
- Frost is meteorological deposition
- Dye sublimation is used in color printing. The solid dye is sublimed and deposited on the paper.
- Volatile contaminants (PCBs, DDT, flame retardants, Toxaphene – prevalent in the southern United States as a pesticide used on cotton plants, HCHs) sublime into the atmosphere and move from areas of use to cooler regions. The cycle if repeated can move these contaminants to Polar Regions. This movement of contaminants is called the “Grasshopper Effect.” These contaminants show up in Inuits and other Artic organisms in higher concentrations than in comparable subjects residing in the source areas. Contaminants from Southeast Asia affect Alaska and Northern Canada and North American contaminants are showing up in Northern Europe. The Southern Hemisphere experiences similar patterns but there are smaller populations south of the equator so less contamination. DDT is presently used for malaria control so there is more DDT than other contaminants.
- Historical – Sublimation is one of the 12 core alchemical processes.

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PHYSICAL SEPARATION TECHNIQUES
PRE-LAB

When two or more substances that do not react chemically are combined together, the result is a mixture in which each component retains its individual identity and properties.

The separation of the components of a mixture is a problem frequently encountered in chemistry. The basis of the separation is the fact that each component has a different set of physical and chemical properties. The components are pure substances that are either elements or compounds. Under the same conditions of temperature and pressure, the properties of every sample of a pure substance are identical. Each sample melts at the same temperature, boils at the same temperature, has the same solubility in a given solvent, etc. Although these and other characteristics can be used to identify a particular substance, we will be concerned in this experiment with the separation of a mixture into its components, not with the identification of the substances. Various techniques are used to separate mixtures, but all techniques rely on differences in the physical properties of the components.

Techniques that are useful for the separation of mixtures include the following:

DISTILLATION is the purification of a liquid by heating it to its boiling point, causing vaporization, and then condensing the vapors into the liquid state and collecting the liquid. Separation of two or more liquids requires that they have different boiling points. All boiling points are lowered by decreasing the pressure on the liquid. .

EXTRACTION is the removal of one substance from a mixture because of its greater solubility in a given solvent.

FILTRATION is the process of removing or "straining" a solid (the chemical term is precipitate) from a liquid by the use of filter paper or other porous material.

DECANTING is the pouring of a liquid from a solid-liquid mixture, leaving the solid behind. .

CENTRIFUGING is the process of separating a suspended solid from a liquid by whirling the mixture at high speed. .

SUBLIMATION is the physical property of some substances to pass directly from

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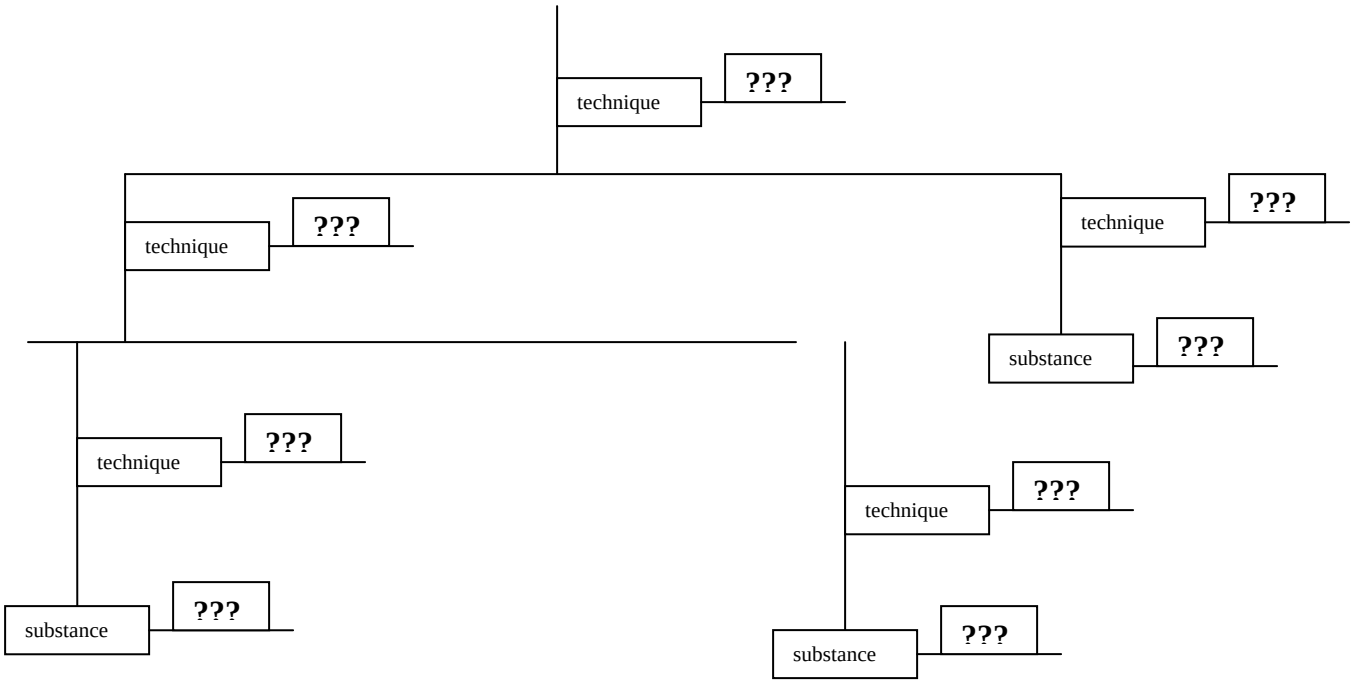
the solid state to the gaseous state without the appearance of the liquid state. Not all substances possess this characteristic. If one component of a mixture sublimates, this property can be used to separate it from the other components of the mixture. Iodine (I_2), naphthalene (mothballs), and dry ice (solid CO_2) are some substances that sublime.

CHROMATOGRAPHY is the process of separating a mixture by the distribution of its components between two phases, one phase being stationary and the other phase moving. Some examples of chromatography are gas chromatography, paper chromatography, and thin-layer chromatography.
In this experiment, you will separate a three-component mixture (containing sodium chloride, ammonium chloride and silicon dioxide) into the pure individual components. Knowing the mass of the original mixture and determining the mass of the pure components will allow you to calculate the percent by mass of each substance in the original mixture.

The separation scheme used to separate the mixture relies on differences in the physical properties (such as boiling point, melting point, solubility in a given solvent, etc.) of the three components.

Chemists frequently illustrate a separation procedure by means of a flow chart as depicted below. By looking up the physical properties of each component in the mixture, they can decide what physical separation techniques will best allow them to separate the mixture. In the pre-lab for this experiment, you will look up the pertinent physical properties of the three components and fill in the missing substances and techniques shown as question marks.



Mixture of NH_4Cl, NaCl, and SiO_2

STUDENT PROCEDURE

NAME _____

SECTION # _____

Physical Separation Techniques

1. Using the CRC Handbook of Chemistry and Physics or other suitable references, look up the following physical properties of ammonium chloride (NH_4CI), silicon dioxide (SiO_2, sand), and sodium chloride (NaCI, table salt).(5 points)

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Physical Properties

Substance	**Formula**	**Melting Point** (°C)	**Solubility*** Grams of solute per 100 g of water	**Appearance**
Sodium Chloride (Table Salt)	NaCl			
Ammonium Chloride (Sal ammoniac)	NH_4Cl			
Silicon Dioxide (Sand)	SiO_2			

2. Using the above physical properties, construct flow chart given on the previous page by giving the reagents and/or conditions necessary to affect each indicated separation step and how the components will be separated. Use the other side of this paper for your chart. (1 point)

3. A student is given a 6.216 g mixture of iron filings, calcium chloride and sand. He separates the mixture and recovers 2.524 g of iron, 1.932 g of sand and 1.523 9 of calcium chloride. Calculate the percentage of each component he recovered from the original mixture and the percent of material he lost during the separation process. (4 points)

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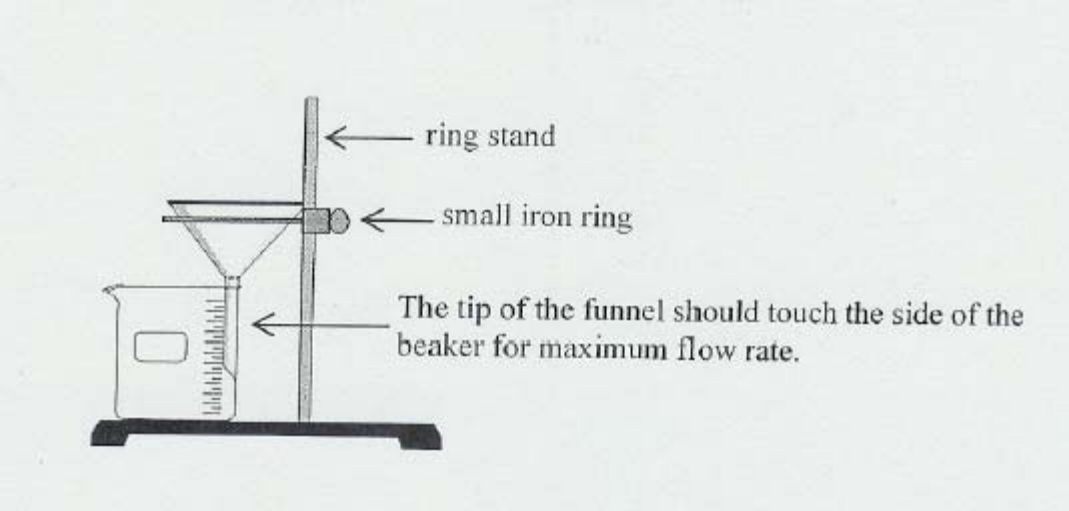
Qualitative Separation of a Mixture

1. Obtain an unknown solid mixture from the instructor. Record the number of the unknown.

2. Separation of solid 1 - NH_4Cl. Place the sample into a 400 or 600 mL beaker and put the beaker on a hot plate in the hood. Slowly and gently, heat the mixture until the white fumes cease. Be patient. Depending on the amount of solid 1 in your sample, this could take quite a while. One hour would not be unheard of. Stir the mixture frequently to facilitate the removal of solid 1. This is crucial in order to obtain good separation. All of the ammonium chloride is removed at this point. After the white fumes disappear, continue heating the mixture until no white solid (NH_4Cl) deposits on a stirring rod held above the beaker. At this point all of solid 1 (NH_4Cl) should be separated. Allow the beaker to cool.

3. Extraction of solid 2 - NaCl. An additional 400 or 600 mL beaker will be used to catch the filtrate. Add between 5 to 7 mL of distilled water to the remaining mixture (NaCl - SiO_2) in the first beaker and stir gently for 5 minutes. Following the procedure outlined by the instructor (see the figure below), filter the sand-salt solution through the filter paper in the funnel into beaker 2. The solution that comes through the funnel (filtrate) should be completely clear. Do not stir the sand in the funnel because the wet filter paper is fragile and will tear easily. Add 5 to 7 mL more distilled water to the evaporating dish to remove the rest of the mixture and pour this through the funnel. If the entire solid is in the funnel, pour the third 5 to 7 mL portion of water directly on the sand in the funnel. If the solid is not all out of beaker 1, pour the last portion of water into it to remove the rest of the sand, making sure that all the water and sand gets into the funnel.



4. Drying of residue – solid 3 (SiO_2.) Carefully place your wet filter paper cone in which the sand is contained onto the watch glass. There is no need to unwrap the cone. The instructor will then place the watch glass into a hot oven; do not go into the oven yourself. After approximately 30 minutes, the water should have all evaporated from the sand. The instructor will check and remove the dry sand and filter paper for you; do not go into the oven yourself. Allow the paper and sand to cool.

5. Drying of solid 2 - NaCl. Set the beaker containing the NaCl solution on a hot plate. Gently heat the solution until the salt is dry. (Start at a low setting and then increase as the water evaporates.) If the salt appears to be dry but there is still water on the beaker walls, see the instructor. If the salt pops out of beaker, carefully remove the beaker from the hot plate and see the instructor.

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Quantitative Separation – Percent Composition of a Mixture

1. Obtain an unknown solid mixture from the instructor. Record the number of the unknown.

2. Separation of solid 1 - NH_4Cl. Weigh a 400 or 600 mL beaker (beaker 1) and accurately weigh the *total solid mixture* into it. Place the beaker on a hot plate *in the hood.* Slowly and gently, heat the mixture until the white fumes cease. Be patient. Depending on the amount of solid 1 in your sample, this could take quite a while. One hour would not be unheard of. Stir the mixture frequently to facilitate the removal of solid 1. This is crucial in order to obtain good results. If not all of the ammonium chloride is removed at this point, your other results will also be off. After the white fumes disappear, continue heating the mixture until no *white solid (NH_4Cl) deposits* on a *stirring rod held above the beaker.* At this point all of solid 1 (NH_4Cl) should be separated. Allow the beaker to cool and record its mass to find the mass of NH_4Cl in the mixture.

3. Extraction of solid 2 - NaCl. Cool and re-weigh the 400 or 600 mL beaker (beaker 2). Weigh a piece of filter paper. Weigh an additional 400 or 600 mL beaker that will be used to catch the filtrate. Add between 5 to 7 mL of distilled water to the remaining mixture (NaCl- SiO_2) and stir gently for 5 minutes. Following the procedure outlined by the instructor (see the figure below), filter the sand-salt solution through the pre-weighed filter paper in the funnel into pre-weighed beaker 2. The solution that comes through the funnel (filtrate) should be completely clear. Do not stir the sand in the funnel because the wet filter paper is fragile and will tear easily. Add 5 to 7 mL more distilled water to the evaporating dish to remove the rest of the mixture and pour this through the funnel. If the entire solid is in the funnel, pour the third 5 to 7 mL portion of water directly on the sand in the funnel. If the solid is not all out of the beaker 1, pour the last portion of water into it to remove the rest of the sand, making sure that all the water and sand gets into the funnel.

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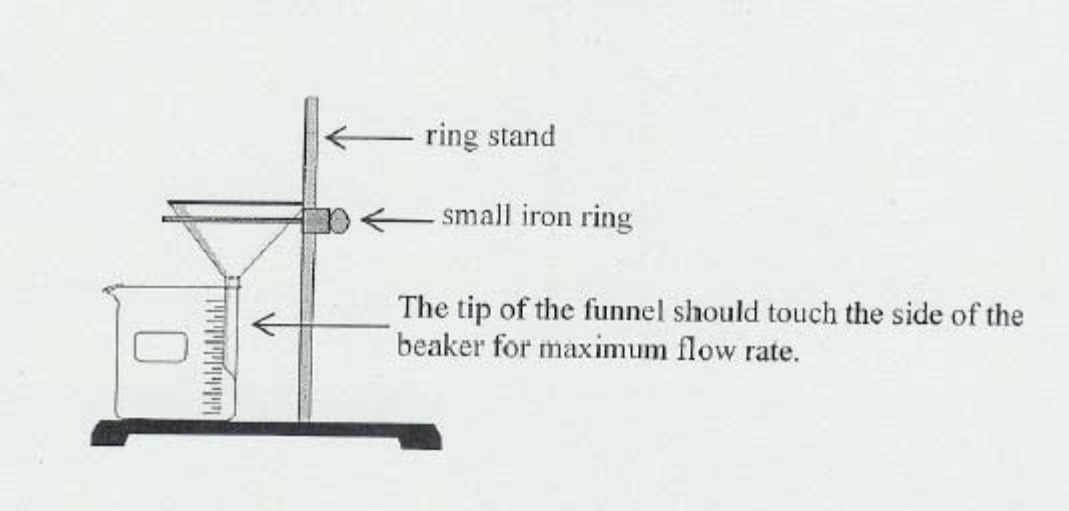

4. Drying of residue – solid 3 (SiO_2.) Weigh a watch glass. Carefully place your wet filter paper cone in which the sand is contained onto the watch glass. There is no need to unwrap the cone. The instructor will then place the watch glass into a hot oven; do not go into the oven yourself. After approximately 30 minutes, the water should have all evaporated from the sand. The instructor will check and remove the dry sand and filter paper for you; do not go into the oven yourself. Allow the paper and sand to cool and then weigh them to find the mass of SiO_2 in the sample.

5. Drying of solid 2 - NaCl. Set the beaker containing the NaCl solution on a hot plate. Gently heat the solution until the salt is dry. (Start at a low setting and then increase as the water evaporates.) Make sure that all the condensation is gone from the sides of the beaker. If the salt appears to be dry but there is still water on the beaker walls, see the instructor. If the salt pops out of the beaker, carefully remove the beaker from the hot plate and see the instructor. When the beaker is cool (check the bottom), weigh it to find the mass of NaCl in the original mixture.

6. Determine the Percent by Mass of each of the components in your mixture using the following formula:

$$\% \text{ yield} = \frac{\text{Mass of individual component}}{\text{Total mass of mixture}} \times 100$$

7. Obtain the actual percentages from the instructor and determine %error.

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ASSESSMENT

Possible Questions

Qualitative:

1. The decomposition of ammonium chloride mimics sublimation. Based on your observations, provide evidence that supports or refutes this claim.
2. How is a flow chart like a road map?
3. Was the filtrate a pure substance? Explain your answer by providing evidence from the lab.
4. If you had been recovering the components and determining percent composition, how could you explain a total percentage of 112%? Discuss at least three possible sources of error and the effect of these errors on the numerical value of the total percentage.
5. Why did you use three small volumes of water to rinse the sand instead of one large volume?
6. If you were to redo this experiment, how would you change the procedure and why?
7. What would you need to do if some of the sand and bits of filter paper were in the beaker along with the filtrate?
8. Describe the appearance of the filtrate during the evaporation phase. Explain what you saw.
9. Why should the salt water be heated more gently as time passes?
10. What is the purpose of initially wetting the filter paper?
11. What are examples of mixtures that you encounter every day?
12. Why was it important to use a hood?

Quantitative:

1. Why is it not necessary to collect the ammonium chloride to determine its mass?
2. The decomposition of ammonium chloride mimics sublimation. Based on your observations, provide evidence that supports or refutes this claim.
3. How is a flow chart like a road map?
4. Was the filtrate a pure substance? Explain your answer by providing evidence from the lab.
5. Why is it important to make sure that all of the water was removed from the salt or the sand?
6. Which component had the greatest % error? Evaluate the results as to possible sources of error are.
7. What effect would using too much water to dissolve the salt have on the results?
8. Would the yield better when if you worked in macroscale or microscale?

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9. What are the major sources of error in your procedure? Would they make your yield too low (loss of product) or too high (addition of contaminants)?

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STUDENT WORKSHEETS

NAME _____

SECTION # _____
Data and Calculations

Unknown Number _____

1. Mass of beaker #1 plus original sample _____

2. Mass of beaker #1 _____

3. Mass of original sample _____

4. Mass of beaker #1 plus NaCl and SiO_2 _____

5. Mass of NH_4Cl in original sample _____

6. Mass of watch glass, filter paper, and dry SiO_2 _____

7. Mass of watch glass _____

9. Mass of filter paper _____

8. Mass of SiO_2 in original sample _____

8. Mass of beaker #2 plus dry NaCl _____

9. Mass of beaker #2 _____

10. Mass of NaCl in original sample _____

Calculations: Show all work
1. Percent NH_4Cl in the original sample. _____

2. Percent SiO_2 in the original sample. _____

3. Percent NaCl in the original sample. _____

4. Percent lost or gained _____

LESSON TWO
What You Can't See Can Hurt You

DEVELOPED BY NORMA ASHBURN

FOCUS

What happens to the chemicals in an industrial cleaner after you pour it into the sink? To the flame retardants used in computers, fabrics, toys? Even the wash water and lint from the dryer have high concentrations of chemicals that may harm the environment. When we dispose of something, the elements present may be rearranged but are still there. Even at low concentrations (ppm or ppb) some chemicals have harmful effects on the environment. In the laboratory of Stephen Christopher mercury concentrations in bird eggs are monitored. Jennifer Keller is setting up benchmarks (standards) for certain persistent emerging contaminants. Her work has been centered on turtles as well as dolphins. Students will serially dilute a solution and identify a certain element through the use of various techniques and instruments of varying sensitivity.

GRADE LEVEL

Grades 9-12

SUBJECT AREA

Chemistry

FOCUS QUESTION(S)

- How can one calculate parts per million, parts per billion, parts per hundred (% mass)?
- How can one calculate number of moles, particles and grams from molarity and gfw?
- How can one make serial dilutions?
- How can technology (CBL and calculator) be used to determine solution concentration?

SOUTH CAROLINA CHEMISTRY STANDARDS

Standard C-1 The student will demonstrate an understanding of how scientific inquiry and technological deign, including mathematical analysis, can be used to pose questions, seek answers and develop solutions.

C-1.1 Apply established rules for significant digits, both in reading scientific instrument and in calculating a derived quantity from measurement.

C-1.2 Use appropriate laboratory apparatuses, technology, and techniques safely and accurately when conducting a scientific investigation.

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C-1.3 Use scientific instruments to record measurement data in appropriate metric units that reflect the precision and accuracy of each particular instrument.
C-1.5 Organize and interpret the data from a controlled scientific investigation by using mathematics (including formulas, scientific notation, and dimensional analysis), graphs, models, and/or technology.

C-1.8 Use appropriate safety procedures when conducting investigations.
Standard C-4 The student will demonstrate an understanding of the types, the causes and the effects of chemical reactions.

C-4.4 Apply the concept of moles to determine the number of particles of a substance in a chemical reaction, the percent composition of a representative compound, the mass proportions, and the mole-mass relationships.

Standard C-6 The student will demonstrate an understanding of the nature and properties of various types of chemical solutions.

Indicator C-6.4 Carry out calculations to find the concentration of solutions in terms of molarity and percent weight (mass).

Ocean Literacy: Essential Principles and Fundamental Concepts

6: The oceans and humans are inextricably interconnected.

> e. Humans affect the oceans in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (point source, non-point source, and noise pollution) and physical modifications (changes to beaches, shores and rivers). In addition, humans have removed most of the large vertebrates from the ocean.

APPROXIMATE TIME

Part 1—
90 minutes (Calculations completed at home or next period)
Part 2—
50 minutes (Extension)

MATERIALS

Per Group:

- 9 Small plastic cups or test tubes
- 10-mL graduated cylinder
- stirring rod
- electronic balance
- 10 mL of1-M cupric sulfate solution
- graduated pipets or 1-mL syringes

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- small dropper bottles of concentrated ammonium hydroxide
- conductivity pen

See list of materials for part 2 Extension

BACKGROUND INFORMATION

Determining the fate of chemicals in the environment and their effects are growing concerns to those who specialize in environmental management. Chemists are studying the particles that have been released from water treatment plants, industrial processes, improper disposal and even volcanic eruptions.

For certain substances the Environmental Protection Agency has set consumption limits on many substances. For methyl mercury in fish the limit set is 0.3 ppm. For lead any amount above 10 micrograms per 100 grams of blood (0.1 ppm) in children is of concern. For cadmium levels of 5 micrograms per 100 grams of blood (0.05 ppm) suggest cadmium toxicity. The advances in the sensitivity of modern analytical techniques make it possible to detect some substances at the parts per trillion level whose presence would not have been detected using earlier assay methods. Researchers at HML are heavily involved in setting up standards for environmental studies. Organo-metals, especially mercury is a major project of Steve Christopher. Jennifer Keller is setting up benchmarks (standards) for certain persistent emerging contaminants. Her work has been centered on turtles as well as dolphins. During the past 50 years, the detection limit has become very small; in some cases, special instruments can detect just a few molecules.

TEACHER TIPS

- Make 1 liter of 1.0-M stock solution of CuSO4. Prepare by placing about 500 ml of distilled water (about half-full) in a liter volumetric flask and adding 249.69 grams of copper sulfate hydrate ($CuSO_4.5H_2O$). You may also warm the water prior to adding or place on a warm hot plate. Shake. Add enough distilled water almost to the fill line and continue shaking until completely dissolved. Allow to cool and then fill to line. Each student group will receive 10 mL of this stock solution. One liter will provide 100 samples. This is very easy to dispense with a 10-mL syringe.
- To facilitate dilution you should give students 8 graduated pipets. Otherwise, they must rinse each time after dilution.
- Do conductivity tests BEFORE adding the concentrated ammonium hydroxide!

Teacher Notes:

Just for your information

Many of the substances considered environmental toxins are present in very small amounts. A part per million is equal to:

- one penny in $10,000
- one minute in two years
- one dime in a one-mile-high stack of pennies

A part per billion is equal to:

- one penny in $10,000,000
- one pinch of salt in 10 tons of potato chips
- one second in 32 years
- one drop of ink in one of the largest tanker trucks used to haul gasoline

OTHER RESOURCES

Web Resources:

http://dwb.unl.edu/Teacher/NSF/C01/C01Links/thechalkboard.com/Corporations/Dow/Programs/1998_NSTA/1998_Lessons/unit798.html

http://delloyd.50megs.com/photo.html

http://dwb.unl.edu/Chemistry/LABS/LABS18c.html#Possible%20Extensions

Flinn Fax Vol.02-1 pp1-2:

http://www.ncsu.edu/labwrite/res/gt/graphtut-home.html

This site gives good instructions for graphing Beer's Law data with Excel.

ASSESSMENT

1. At which concentration could you no longer detect the blue color of the copper ion with your eyes? Did this change once the ammonium hydroxide was added?

2. At sample of contaminated water is suspected to contain copper (II) ions. Addition on $NH_3(aq)$ does not produce the typical deep blue color of the $Cu(NH_3)_4^{2+}$ ion. Does this mean that absolutely no copper(II) ions are present?

3. Which solutions contained copper ions?

4. Which solutions conducted an electrical current (using the conductivity pen)? If there were any that did not conduct, explain in terms of number of copper ions.

5. Give an example of a chemical pollutant that is not detectable by our senses but causes harm to people or the environment.

6. Given 100 mL of 1.0-M HCl, how would you make 100 mL of 0.1-M HCl?

7. A caffeine concentration of 192 ppm will kill, on average, 50% of a population. The molecular mass of caffeine is 194.19grams. How many grams of caffeinewould possibly kill a 150 lb person? (1 kg = 2.2 lbs.)

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STUDENT PROCEDURE

Name_____

Part 1

Procedure:

1. Place 10 ml of 1-M $CuSO_4$ in each of the test tubes.
2. Remove 1 ml of Solution 1 and place in test tube #2. Stir.
3. Remove 1 ml of Solution 2 and place in test tube #3. Stir.
4. Continue this procedure until all 9 of the test tubes have 10 mL of solution.
5. Calculate the molarity of the solution in each test tube.
6. Calculate the number of moles of copper ions in each test tube.
7. Calculate the number of copper ions in each test tube.
8. Calculate the mass of copper ion in each test tube.
9. Calculate the ppm of copper in each solution.
10. Calculate the ppb of copper in each solution.
11. Calculate the % by mass of copper in each solution.
12. Compare the colors in each test tube. Place a white paper behind the test tubes for better viewing.
13. Test the conductivity of each solution with a conductivity pen. (Be sure to rinse with distilled water after each test.). You may also test with a conductivity probe if one is available.
14. Add one drop of concentrated ammonium hydroxide to each (or teacher may do this).
15. Observe the color of each solution again.

DATA TABLE

Test tube #	M	Moles of Cu^{++}	# of Cu^{++}	G of Cu^{++}	Ppm of Cu^{++}	Ppb of Cu^{++}	% mass Cu^{++}	Con-ductivity	Color	Color with NH_4OH
1	1.0-M	0.01	6.02×10^{21}	.635	6.35×10^{4}	6.35×10^{7}	6.35 %			
2										
3										
4										
5										
6										
7										
8										
9										

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Show all calculations!

Sample Calculations

Test tube #1

Moles of Cu^{++} = (molarity) (volume)

= (1.0-M)(10 mL/1000mL/1L)

= 0.01 mole of Cu^{++}

# of Cu^{++} = (moles of Cu^{++})(N)

= (0.01 moles Cu^{++})(6.02×10^{23} ions/mole)

= 6.02×10^{21} Cu^{++} ions

G of Cu^{++} = (moles of Cu^{++}) (grams/mole)

= 0.01 mole)(63.5g/mole) = 0.635 g

****For ppm see ISE molarity/ppm conversions at

http://delloyd.50megs.com/photo.html

Molarity = ppm/gfw(1000)

From the chart at this site 1-M Copper =63,500 ppm

Ppm of 1-M = (atomic mass)(1000)

= (63.5)(1000) = 63,500ppm or 6.35×10^4 ppm

Ppb of 1-M = (ppm)(1000)

= (63,500)(1000) = 63,500,000 or 6.35×10^7 ppb

Parts per hundred or % mass

Ppm (parts per million) to % (parts per hundred)

Ppb for 1-M = 63,500part/1000000parts = 0.06350

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Parts per hundred or per cent = 6.35%

Part 2 (Extension)

Measuring the Absorbance and % Transmittance Using CBL
This activity affords the students an opportunity to use technology to detect smaller concentrations of solutions.

Materials

- Colorimeter with 9 cuvettes
- Texas Instruments CBL
- TI-83 calculator
- Vernier CHEMBIO program for TI-83 (available free from Vernier)
- Graph Link software (optional)

Assessment

1. Did the colorimeter enable you to detect a difference between each concentration? Explain.
2. Graph absorbance vs concentration.
3. Graph % transmittance vs concentration.
4. Which of the graphs is more linear? Discuss the reason for the differences.
5. You make a series of solutions of $CuSO_4 \cdot 5H_2O$, using the masses shown below and a 100 mL volumetric flask.
    a. Calculate the molarity of each solution.
    b. Determine the absorbance of each of these standard solutions, using A = -log(%T/100).
    c. Graph A vs. c.
    d. What is its concentration a solution of copper (II) sulfate pentahydrate which transmits 96% of the light through this colorimeter ?
    e. [*] Determine the %T expected from a solution made with 0.85 g $CuSO_4 \cdot 5H_2O$ and a 100 mL volumetric flask. Note that %T = $(10^{-A}) \times 100$.

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Concentration (M)	%Transmittance
0.000	100.0
0.010	96.6
0.030	90.2
0.050	83.9
0.070	78.0
0.090	72.4

Mass of solute (g)	%Transmittance
0.000	100.0
0.252	94.5
0.501	89.4
0.749	84.6
1.020	79.6

OPTIONAL EXTENSIONS

Copper in Drinking Water

There is concern about an increasing amount of copper(II) ion in drinking water.

a. Find out what commercial products contain copper(II) ions. For example, visit the local hardware or seed store. Read labels on such items as fertilizers, herbicides, pesticides, algaecides, etc.
b. $CuSO_4 \cdot 5H_2O$ is added to swimming pools and ponds to control algae. Bring in a water sample from a local pool or treated pond. Run a test for copper(II) ion.
c. Gather samples of runoff water from fertilized fields, drainage ditches, or wherever copper(II) ion pollution might be found. Analyze the samples.

Disposal of Household Products

May these substances safely be poured down the drain when you are finished using them? If not, how should you dispose of them?

1. Antifreeze (ethylene glycol)
2. Weed killer or insecticides
3. Used motor oil
4. Detergents
5. Vanish drain cleaner
6. Woolite cold water wash
7. Ammonia
8. Latex paint
9. Paint thinner

10. Hydrogen peroxide
11. Nail polish remover
12. Pepto-Bismol
13. Fluoride treatment
14. Rubbing alcohol
15. Vegetable scraps (garbage disposal)
16. Grease (from bacon or cooking)

Answers to the Disposal Extension

1. No; antifreeze (ethylene glycol) is biodegradable by bacterial action ("bugs"); however, it is very poisonous even in small amounts to pets and people, so it should be disposed of so that there is no danger to them. Read the label for instructions on proper disposal.
2. No; weed killer and insecticides may be toxic to fish and may not be readily biodegradable. They also may kill the "bugs" (bacteria) at the wastewater treatment plant. Read the label for instructions on disposal. The safest disposal method is to take them to a hazardous waste collection center.
3. No; used motor oil may not be disposed of down the drain or poured on the ground. It does not biodegrade, and it contaminates our groundwater. It should be recycled.
4. Maybe; detergents and shampoos may contain phosphates or surfactants that may not be biodegradable. Read the label or other information provided with the product, or contact the manufacturer.
5. Yes; Vanish cleaner is mostly sodium acid sulfate, a salt which may be washed down the drain.
6. Yes; Woolite wash contains no phosphates, and the organic surfactants are biodegradable.
7. Yes; ammonia decomposes.
8. No; but latex paint is degradable and may be safely disposed of in a sanitary landfill.
9. No; paint thinner is not biodegradable. If flushed down the drain or poured on the ground, it contaminates the groundwater. It should be taken to a hazardous waste collection center or recycled.
10. Yes; hydrogen peroxide decomposes into oxygen and water.
11. Yes; nail polish remover is degradable.
12. Yes; Pepto-Bismol is degradable.
13. Yes; fluoride treatment is a salt that is not harmful to the environment.
14. Yes; rubbing alcohol is degradable.
15. Yes; vegetable scraps may be safely disposed of in the garbage disposal; however, a more cost-effective method is to compost.
16. Yes; although grease can clog drains and damage septic systems, it will degrade eventually and causes no environmental damage

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Name _____

Student procedure:

1. Connect the colorimeter to the CBL with a CBL-DIN adapter in Channel 1, and link the TI-83 calculator to the CBL with a link cable. Turn on the CBL and the calculator. Press the PRGM key on the calculator and select the CHEMBIO program. Follow the prompts on the calculator to collect data for the experiment.
2. Perform a two-point calibration (0% and 100% transmittance) for the colorimeter and CBL with the TI-83. Use red LED (650 nm).

   a) First, close the lid of the colorimeter, set the colorimeter knob to 0% T, and allow the reading on the CBL to stabilize. Press the [Trigger] button on the CBL and enter 0 when asked to Enter Reference.

   b) Set the knob on the colorimeter to 650 nm and insert a blank cuvette (containing distilled water only). Allow the reading on the CBL to stabilize and press the [Trigger] button on the CBL. Enter 100 at the Enter Reference prompt.

3. Fill each cuvette to the line with successive dilutions of solution that were prepared in **Concentration!** lab. To use the calculator to store the data, use the trigger/prompt mode on the calculator program and enter the concentration of each solution when requested. Note: The calculator will store concentration in List 1, absorbance in List 2, and percent transmittance in List 3.

Solution #	Molarity	Molarity (exp)	% Transmittance	% Absorbance	Color
1	1.0	10^{0}			
2	0.1	10^{-1}			
3	0.01	10^{-2}			
4	0.001	10^{-3}			
5	0.0001	10^{-4}			
6	0.00001	10^{-5}			
7	0.000001	10^{-6}			
8	0.0000001	10^{-7}			
9	0.00000001	10^{-8}			

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LESSON THREE
Structure Determines Function

DEVELOPED BY CLARICE WENZ

FOCUS
This activity will demonstrate how small differences in the structure of a compound can result in obvious differences in the properties of that compound. This is a very important concept, since small changes in structure can have a great influence on the biological activity of a compound.

GRADE LEVEL
Grades 10 – 12

SUBJECT AREA
Chemistry

FOCUS QUESTION(S)
- Have you ever wondered why a specific enzyme will only increase the rate of a specific reaction?

SOUTH CAROLINA CHEMISTRY STANDARDS
Standard C – 1: The student will demonstrate an understanding of how scientific inquiry and technological design, including mathematical analysis, can be used appropriately to pose questions, seek answers, and develop solutions.

C-1.2 Use appropriate laboratory apparatus, technology, and techniques safely and accurately when conducting a scientific investigation.

C-1.8 Use appropriate safety procedures when conducting investigations.

Standard C – 3: The student will demonstrate an understanding of the structures and classifications of chemical compounds.

C-3.3 Explain how the types of intermolecular forces present in a compound affect the physical properties of compounds (including polarity and molecular shape).

C-3.5 Illustrate the structural formulas and names of simple hydrocarbons (including alkanes and their isomers and benzene rings).

C-3.6 Identify the basic structure of common polymers (including proteins, nucleic acids, plastics and starches).

C-3.7 Classify organic compounds in terms of their functional group.

Ocean Literacy: Essential Principles and Fundamental Concepts

6: The oceans and humans are inextricably interconnected.

> e. Humans affect the oceans in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (point source, non-point source, and noise pollution) and physical modifications (changes to beaches, shores and rivers). In addition, humans have removed most of the large vertebrates from the ocean.

APPROXIMATE TIME

Teacher prep time: 25 minutes
Total time to present: one 90 minute class period

MATERIALS

Listed for each lab and demonstration within the activity

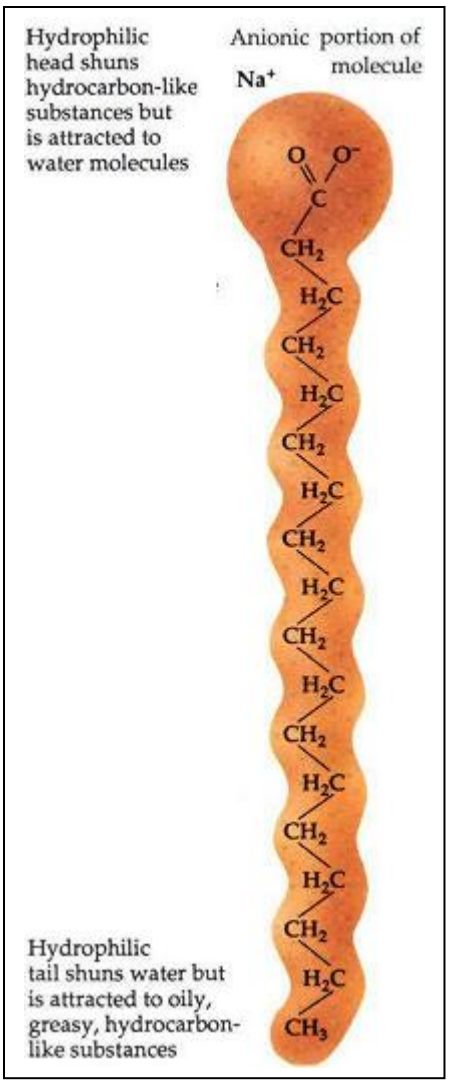
BACKGROUND INFORMATION

Bonding and chemical structure can be taught throughout an introductory chemistry course. These concepts are very important in any chemistry class and can be presented at various levels of comprehension. Most chemical reactions can be explained in terms of the rearrangements of bonds. As reactants are transformed to products, bonds in reactant substances are broken and bonds in product substances are formed. The basic concepts that apply to inorganic reactions in the laboratory, also apply to the changes that occur inside living systems. Using biochemical substances and examples in introductory chemistry courses offers an excellent opportunity to relate our abstract subject to something more concrete. These biochemical examples also offer an opportunity to show commonalities across disciplines.

This activity will tie inorganic chemistry with biology and marine science. This activity is designed to show how isomers of the same compound have different properties. The depth to which you cover this topic is a personnel choice. It will be covered here at a very basic level.

This activity is designed to be used after you have thoroughly taught drawing Lewis dot diagrams and predicting molecular geometry, including isomers and resonance. This laboratory activity provides students evidence of the unique nature of isomers. This concept is very important. After covering the concepts of structural isomerism, students should be able to draw alternate Lewis structures for some basic organic compounds (naming these compounds is not usually taught until later in the course). It is very important to be sure that the students understand the difference between isomeric structure and resonance structures. Isomers have the same molecular

formula, but different structural formulas, giving them different properties. In drawing resonance structures, a multiple bond is drawn in a different place. Resonance structures for the same compound have the same molecular formula, the same structural formula, and the same properties. This is because we cannot accurately draw the bonds in these compounds because they have delocalized electrons.



While the demonstrations and laboratory given in this activity are used primarily to show that different tastes and/or odors result from different structures, it is important to include more examples of how the basic structure of a molecule determines the properties of that molecule. Examples could include a quick demonstration during your discussion relating rates of evaporation of compounds such as ethanol, 1-propanol, and acetone. Simply place each of the substances on a separate cotton ball and wipe each in an even, continuous, downward motion on the chalkboard (or surface on which they can be seen, but will not be absorbed or damage the surface). Do them at the same time and notice the rate at which each evaporates. Discuss the effects of intermolecular forces on the rates of evaporation. Keep in mind that you are emphasizing the fact that the structure of molecule determines its properties and how it functions.

The importance of structure to function can be shown with the example of the soap molecule. An example of a crude soap molecule, $CH_3(CH_2)_{14}CO_2Na$ shows that soap has a hydrophilic and a hydrophobic end.

The hydrophilic end, containing the carboxylic acid group (COOH), is attracted to water molecules but not to hydrocarbon-like molecules (oils and greases). The hydrophobic end, containing a methyl group (CH_3), is attracted to the oily, greasy hydrocarbons, but not to water molecules. This dual nature enables the soap to clean the oil and grease from materials while in water. (If more information is needed for this discussion, refer to a good first year or AP chemistry textbook or textbook).

This dual nature is also found in one of the emerging contaminants currently being studied by NOAA, NIST, and HML. These contaminates are collectively called hydrophobic

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perfluorinated chemicals (PFCs). PFCs are compounds consisting of long carbon chains of varying lengths to which fluorine atoms are strongly bonded. These are industrially made compounds which are produced in large amounts. These compounds are generally resistant to degradation and environmental breakdown. PFCs are also bioaccumulative and toxic. The health effects have been studied in animals but not in humans. PFCs are known to be toxic to birds and bees. (Could this be a cause of the recent decline in the bee population of the United States?)

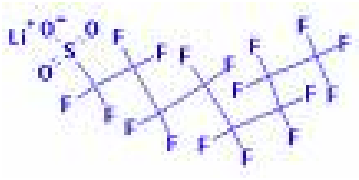
PFCs have been detected in lakes, oceans, sewage sludge, rainwater, indoor and outdoor air, household dust, and wildlife. Wildlife found to contain PFCs include polar bears, dolphins, sea turtles, minks, river otters, bald eagles, and wood mice. The concentrations in these animals appear to be increasing especially in those from the polar regions and northern latitudes.

These compounds are commonly used and found throughout the environment. PFCs are found in nonstick coatings, stain and water repellant treatments for carpets, furniture, and clothing, paper coatings, cleaning products, surfactants, pesticides, floor polish, shampoo, food packaging material, and fire fighting foam.

PFCs are definitely chemicals that will be discussed more frequently in future media publications. One of the important properties of these compounds is their hydrophilic and hydrophobic nature which enables them to repel both water and oil and to be attracted to both water and oil. PFCs are found in both the blood and livers of animals. They also bind to proteins. These properties are important because the PFCs are then able to get to target tissue in the body.

Systematic Names:
1-Octanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,8-heptadecafluoro-, lithium salt
Lithium heptadecafluorooctanesulphonate

Structure:



Both PFCs and soaps are used in surfactants and both have hydrophobic and hydrophilic ends. The discussion of PFCs is related to marine science and ocean literacy because it appears that this contaminant is spreading rapidly throughout our environment by way of ocean life showing that ours lives are intimately related to the oceans.

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While all of the above discussion is to give the teacher background information, please keep in mind that you are using this information to enable the student to better see the dependent of the properties of a compound on the structure of that compound.

TEACHER TIPS

The teacher tips are included in the previous discussion.

WORKS CITED

http://assets.panda.org/downloads/fact_sheet___pfcs_food.pdf

http://en.wikipedia.org/wiki/carvone

http://www.scientificpsychic.com/fitness/carbohydrates1.html

Case, Mark; Woodrow Wilson Foundation Binder Chemistry Team 6 Binder

STUDENT PROCEDURE

Demonstration Number One:

Taste + Odor = Flavor

Purpose:

This demonstration shows that odor as well as taste contributes to the flavor that we associate with certain foods.

Time:

Teacher prep time: 5 minutes
Demonstration time: 30 minutes

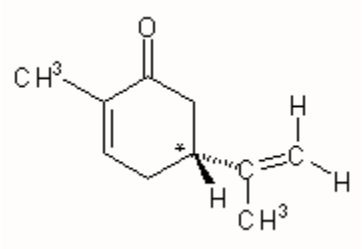
Materials:

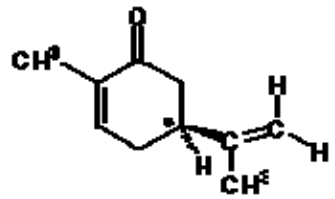
Caraway seed oil
Spearmint oil

Procedure:

Begin the demonstration by passing around one vial containing R(-) carvone [laevo carvone] and one vial containing S(+) carvone [dextro carvone]. The vials can be prepared by placing cotton balls into the vial and soaking them with the oils. Ask the students to identify these odors. Discuss the fact that these two molecules are optical isomers (or enantiomers or stereoisomers) and they differ only in the spatial arrangement about one of the carbon atoms in the ring. See diagrams below;

(-) carvone





(+) carvone

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They are mirror images of each other. They are not identical because even when turned and rotated, the top molecule cannot be superimposed on the bottom molecule so that all of the atoms and bonds match. Have the students look into a mirror at the image of their hand and try to mentally superimpose the image onto their hand.

Your nose can tell the difference apart. S (+) carvone smells like caraway seeds and the R (-) carvone smells like spearmint. The difference in structure is easily distinguished by the olfactory receptors in our noses.

The flavor commonly known as spearmint has very little effect on the taste receptors and is primarily due to odor. This can be illustrated by chewing a piece of spearmint gum while holding your nose. You will taste almost nothing, but when you release your nose and allow the odor to affect the flavor, you will experience a burst of spearmint. Hold your nose again and the taste will disappear again. This can be repeated several times while chewing your gum.

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Laboratory Activity:
Teacher Information:

How Sweet It Is

Purpose: In this laboratory a comparison will be made between the relative sweetness of various mono- and disaccharides. This lab will also compare the structures of these sugars.

Caution: This lab activity involves tasting various chemicals. Make sure that all containers and utensils used are designated for food use only. Be careful to avoid accidental contamination among the students. This lab should be done in the classroom section of your room since all of the students know that a very important safety rule is never taste anything in the laboratory.

Time:
Teacher prep time: 20 minutes to cut straws
Laboratory time: 45 minutes

Materials:
A straw made into a scoop (one for each student)
6 plastic cups (one for each of the 6 sugars)
25 g of each of the following: (Can be obtained from any chemical supply house.)
- Glucose
- Galactose
- Fructose
- Maltose
- Lactose
- Sucrose

Procedure:
1. Examine the structure of these common sugars (see following reference sheet of information)
2. Describe how they differ
3. Locate each of the sugars around the room. With your straw scoop obtain a small sample of one sugar sample and **pour** it onto you tongue. DO NOT ALLOW YOUR SCOOP TO TOUCH YOUR TONGUE OR ANY PART OF YOUR MOUTH. If this does happen, discard your scoop and get a new one. For best results rinse your mouth with water before moving to the next sample. Describe the taste with degrees of sweetness (from 5 to 1 with 5 being most sweet).
4. Repeat step three for each of the sugars. Repeat samples as needed.
5. Throw all scoops away.

6. Compare your results with the rest of the class and prepare a table to summarize the group results.

Analysis:

1. Examine the molecular structures of the sugars based on your placement of them in the 1 to 5 scale of sweetness. Are there any structural similarities or differences among the sugars in the groups that might explain the results?
2. What are some possible explanations for any lack of consistency among student results?

Assessment:

1. Draw the structure of pentane.

2. Draw all possible isomers of pentane.

Name _____

Student Procedure:

Safety: Since you will be tasting these sugars, be very careful with your scoops. Please pay close attention to step 3 in the procedure below.

1. Examine the structure of these common sugars (see following reference sheet of information)
2. Describe how they differ
3. Locate each of the sugars around the room. With your straw scoop obtain a small sample of one sugar sample and **pour** it onto you tongue. DO NOT ALLOW YOUR SCOOP TO TOUCH YOUR TONGUE OR ANY PART OF YOUR MOUTH. If this does happen, discard your scoop and get a new one. For best results rinse your mouth with water before moving to the next sample. Describe the taste with degrees of sweetness (from 5 to 1 with 5 being most sweet).
4. Repeat step three for each of the sugars. Repeat samples as needed.
5. Throw all scoops away.
6. Compare your results with the rest of the class and prepare a table to summarize the group results.

<u>Assessment:</u>

1. Draw the structure of pentane.

2. Draw all possible isomers of pentane.

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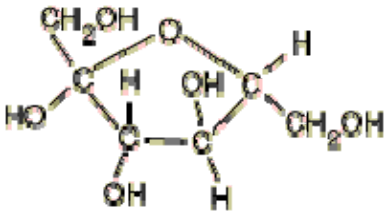
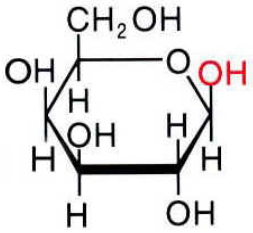
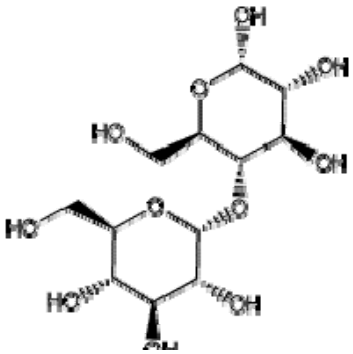
Reference Page for Sugars



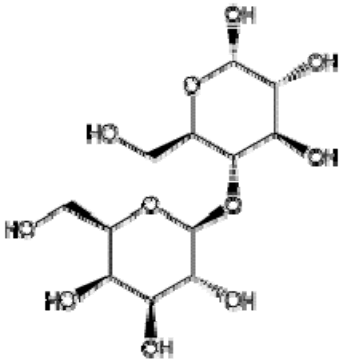
Fructose



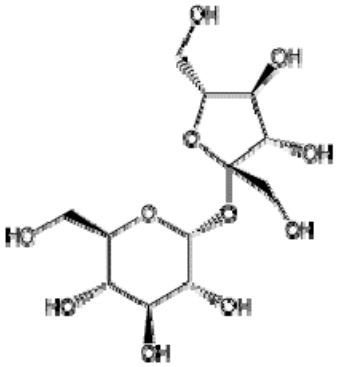
Galactose



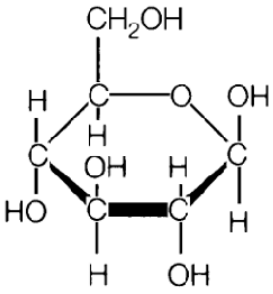
Lactose



Maltose



Sucrose



Glucose

LESSON FOUR
Single Replacements Reactions with a Twist

DEVELOPED BY CLARICE WENZ

FOCUS
This activity gives each student the opportunity to observe and experience a single replacement reaction. This activity also gives the teacher an opportunity to show the relevance of single replacement reactions and to relate chemistry standards with the Essential Principles of Ocean Literacy.

GRADE LEVEL
Grades 10-12

SUBJECT AREA
Chemistry

FOCUS QUESTION(S)
- Have you ever wondered how a battery works?

SOUTH CAROLINA CHEMISTRY STANDARDS
Standard C–1: The student will demonstrate an understanding of how scientific inquiry and technological design, including mathematical analysis, can be used appropriately to pose questions, seek answers, and develop solutions.

C-1.2 Use appropriate laboratory apparatuses, technology, and techniques safely and accurately when conduction a scientific experiment.

C-1.3 Use scientific instruments to record measurement data in appropriate metric units that reflect the precision and accuracy of each particular instrument.

Standard C–4: The student will demonstrate an understanding of the types, the causes, and the effects of chemical reaction.

C-4.1 Analyze and balance equations for simple synthesis, decomposition, single replacement, double replacement, and combustion reaction.

C-4.7 Summarize the oxidation and reduction processes (including oxidizing and reducing agents).

C-4.8 Illustrate the uses of electrochemistry (including electrolytic cells, voltaic cells, and the production of ore by electrolysis)

Ocean Literacy: Essential Principles and Fundamental Concepts

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6: The oceans and humans are inextricably interconnected.

e. Humans affect the oceans in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (point source, non-point source, and noise pollution) and physical modifications (changes to beaches, shores and rivers). In addition, humans have removed most of the large vertebrates from the ocean.

APPROXIMATE TIME

Total teacher prep time: one hour
Total time to present: This will vary depending on your style and the students in your class – approximately two 90 minute class periods

MATERIALS

The materials will be listed as each demonstration or activity is given within this document.

BACKGROUND INFORMATION

After introducing students to the types of chemical reactions (Standard C – 4, Indicator C – 4.1), you will want to have your students perform at least one lab for each of the five reaction types. This activity includes two demonstrations and one lab activity that can be used to illustrate single replacement reactions. This activity gives you the opportunity to expand the students' knowledge to include Indicator C – 4.7. The laboratory activity given is making a simple electrochemical cell which covers Indicator C – 4.8 showing the use of electrochemistry in a voltaic cell.

The following information can be used for a discussion before any activities are used, between the demonstrations and the student activity or after the student activity. The discussion can also be broken up into different parts and used individually throughout this activity.

Single replacement reactions can also be classified as oxidation – reduction reactions. When a metal reacts with a nonmetal, an ionic compound is formed. The ions are formed because the metal transfers one or more electrons to the nonmetal, the metal atom becoming a cation and the nonmetal atom becoming an anion. A metal – nonmetal reaction can always be assumed to be an oxidation – reduction reaction, which involves electron transfer. These are certainly not the only type of reduction – oxidation reactions, but this activity will involve only those reactions identified as single replacement.

Mercury is an element that fascinates most students. Using mercury as a topic of discussion will usually hold students' interest. The following paragraphs build to show some of the relationships among mercury, ocean literacy, and redox reactions.

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All chemistry teachers know that the use of mercury in the classroom in no longer allowed. Mercury thermometers, barometers, and manometers have been removed from almost all public school classrooms. Mercury is one of the many metals that is widely distributed in our environment and that most students will recognize as a poison. Other metals that are known as poisons include lead, arsenic, cadmium, beryllium, and hexavalent chromium. Many students are interested in mercury poisoning due to the many past examples that are well known and often repeated such as the "mad hatters" story (the use of mercury in the pre-industrial hat industry as a softener for animal hides resulting in numerous cases of the hatters going "mad"). Consumers have been made aware through the media that many of our fish have been contaminated with mercury and that as we consume more and more fish in our diets, we may be consuming more mercury as well. Mercury is also a concern among the many people who enjoy fish as a major part of their diet. Certain forms of mercury are found in both fresh water and salt water fish. This is an excellent time to include an ocean literacy principle in your chemistry classroom. Principle number 6 states that the oceans and humans are inextricably interconnected. This discussion can show students this with the concern of mercury poisoning from the fish that we eat.

One of the many jobs of NIST (National Institute of Standards and Technology) is to test the mercury found in different animals. Dr. Steven Christopher from NIST, who works at Hollings Marine Lab in Charleston, SC, explained that in testing the mercury concentration in fish, the technique uses a simple redox (reduction – oxidation) reaction between mercury and tin. The mercury in the fish is in the Hg^{+2} form, usually as a methyl mercuric salt such as CH_4HgCl_2. The mercury (II) cation is pulled from the tissue using nitric acid and heating the sample in a microwave oven. This sample containing the Hg^{+2} ions is fed into a gas liquid separator where the redox reaction takes place. The reaction that is used is:

$$Hg^{+2} + Sn^{+2} \rightarrow Hg^{0} + Sn^{+4}.$$

The mercury from the sample is then sent into a mass spectrometer for analysis, giving the scientist the concentration of the mercury in that fish.

Depending on the level of your students, you might choose to show the half reactions that make this overall reaction and have the students balance them. This reaction does occur in an acidic solution.

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STUDENT PROCEDURE

Name_____

Safety: All chemicals are to be handled with care. Do not touch any of the solutions. If a solution accidentally comes into contact with your skin, wash it off immediately in the sink. Never taste any chemical. Wear aprons, safety glasses, and close toed shoes throughout the laboratory activity.

1. Cut a rectangular piece of filter paper so that it fits into the petri dish.
2. Place a piece of copper metal and zinc metal onto the filter paper about 3 cm apart.
3. Place two drops of 1 M copper (II) sulfate at the edge of the copper metal.
4. Repeat step 3 with the zinc metal and the zinc sulfate solution.
5. Place two drops of potassium nitrate solution between the two metals. This will serve as the salt bridge.
6. Switch the multimeter to DC volts and turn on. Place the red probe on the copper metal and the black probe on the zinc metal. Record the voltage reading. Voltage Reading _____
7. Reverse the probes in step 6 and record voltage reading.
   Voltage reading_____

Questions:
(To be answered by each student)

1. Which of the two metals used, zinc or copper, is more reactive?

2. Based on the data that you recorded, in which direction (from zinc to copper or from copper to zinc) do the electrons flow in this electrochemical cell?

3. How did you reach the conclusion given in question 2?

4. If you made a cell using the metals magnesium and silver, which way would you

5. How would you test your prediction from question number 3?

6. Write and balance the chemical equation for the reaction of zinc with a solution of silver nitrate.

7. In the aluminum foil and copper (II) chloride demonstrations, in which direction did the electrons flow? (from copper ions to aluminum or from aluminum to copper ions)

Work Cited

Creech, Denise; Woodrow Wilson Foundation Chemistry Team 6 Bo

Demonstration # 1 The Mighty Chemistry Teacher
(from FlinnFax Vol.06-3 The Can Ripper)

If you used this earlier in the year to demonstrate your chemical strength, now is the perfect time to explain the chemistry behind your "muscle power."

Time:
Teacher prep time: 15 minutes
Demo time: 1 to 5 minutes depending on your approach

Materials:
Aluminum soda can
Copper (II) chloride
Water
Triangular file

Safety:

- Do not leave cans containing the copper (II) chloride solution sitting out. Someone might think they contain soda and take a drink.
- Torn can have sharp edges. Handle carefully to avoid cuts.
- Copper (II) chloride is a body tissue irritant and is highly toxic by ingestion.
- Wear splash proof goggles and safety apron.

Preparation and Procedure:

1. Using a triangular file, score the inside of the can. Score a complete line around approximately the middle of the can.
2. Add 2 to 3 g of $CuCl_2$ to the can.
3. Add enough water to cover the scoring inside the can. Warm water can be used if you are pressed for time.
4. Wait approximately 5 minutes or until you see a darkening on the outside of the can that corresponds to the inside scoring.
5. Pour out the solution and rinse the can well with water.
6. When you are ready to break the can, hold the can horizontally and grasp with both hands so that the scoring is between your hands.
7. Twist your hands in opposite directions to rip the can in half along the scoring. The can should rip with a firm twist.

Tips:

- Either anhydrous or dihydrate copper (II) chloride may be used.

Discussion:
Aluminum cans are lined with a plastic coating to prevent liquid from reacting with the metal. The scoring breaks the coating and exposes the aluminum metal to the

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copper (II) chloride. An oxidation – reduction reaction occurs as the copper (II) ions oxidize the aluminum metal to aluminum ions according to the following equation:

$$3Cu^{+2}(aq) + 2Al\ (s) \rightarrow 3Cu\ (s) + 2Al^{+3}$$

When the reaction is complete, only the ink and coating on the outside of the can are holding the can together.

This would be an appropriate time to discuss the activity of metals and how the single replacement reaction actually occurs. Following an activity discussion, students could be asked to predict what other solutions could be used on the aluminum can. If you have discussed redox half reactions, you could also have the students write and balance the half-reactions.

Demonstration # 2: A Showy Aluminum – Copper Reaction
(from Foiled Again – FlinnFax Vol. 02-1)

Introduction:
Watch aluminum foil disappear as it is added to a green-blue solution of copper (II) chloride. Observe color changes, production of a gas, formation of a metallic copper, and a change in temperature. Learn the crucial role of a catalyst as the single-replacement, oxidation – reduction reaction proceeds.

Time:
Teacher prep time: 15 minutes
Demo time: 30 minutes
Materials:

- One piece of aluminum foil approximately 6" x 12"
- Copper (II) chloride 300 mL of 0.5 M solution
- Graduated cylinder, 500 mL
- Pyrex beaker, 600 mL
- Stirring rod

Safety:

- Copper (II) chloride is toxic by ingestion
- Hydrogen gas (which is produced in a very small amount) is highly flammable
- Wear splash proof goggles and apron

Procedure:

1. Measure 300 mL of 0.50 M $CuCl_2$ solution into the 600 mL beaker
2. Loosely crumple the foil enough to fit into the beaker. Do not wad up the foil tightly – this will decrease the surface area and the reaction will be very slow.
3. Place the aluminum foil into the solution in the beaker. Use a stirring rod to push the foil completely into the solution.
4. Have students record detailed observations of the reaction.
5. Have students generate hypotheses as to the reactions occurring in the beaker.
6. Have students write equations for their hypothesized reactions.

Extensions:

1. Test for the presence of hydrogen gas. Hold a burning splint above the bubbles that are released from the reaction. A positive test is indicated if a barking sound is heard,

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2. Test for the presence of oxygen gas. Hold a glowing splint over the bubbles that are released from the reaction. A positive test is indicated if the splint reignites.

Disposal:

- Allow the contents of beaker to settle.
- Decant the solution from the solid down the drain according to Flinn Suggested Disposal Method #26b.
- Dispose of the solid copper and leftover aluminum according to Flinn Suggested Disposal Method #26a.

Discussion:

This is a single replacement or redox reaction.

This overall reaction is:

$$2\ Al\ (s) + 3CuCl_2\ (aq) \rightarrow 2\ AlCu_3\ (aq) + 3\ Cu\ (s)$$

Students should notice that this reaction is very exothermic and that that the color of the solutions changes from green-blue to colorless. Students should also notice that the silver aluminum foil changes to something that is more reddish in color.

Students should recognize that the aluminum is being oxidized from solid Al^0 to Al^{+3} in the solution and that the Cu^{+2} ions (shown by the green-blue color) are being reduced to Cu^0 in the solid form. The copper metal settles to the bottom of the solution. When all of the copper (II) ions have been reduced, the solution will be colorless.

The test for hydrogen gas should have been positive. The test for oxygen gas should have been negative. The hydrogen gas is produced when the hydrogen ions in the slightly acidic $CuCl_2$ solution are reduced by the aluminum to hydrogen gas.

The reaction is:

$$2\ Al\ (s) + 6\ H^+(aq) \rightarrow 2\ Al^{+3}(aq) \text{ to } H_2\ (g)$$

There is a limited amount of hydrogen ions in the solution so this part of the reaction uses only a small part of the aluminum foil.

If time allows, student hypotheses can be tested by using different solutions with the foil. Suggestions include 0.5 M copper (II) sulfate (no reaction), 0.5 M sodium chloride solution (no reaction), or a mixture of copper (II) sulfate and sodium chloride solutions (reaction does occur). The details of the chemistry for this explanation can be found in the acidity of the copper (II) chloride solution – both of the other solutions

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are closer to neutral. The reaction does not occur unless there are available hydrogen ions. This is a topic not usually covered in first year chemistry. This reaction could be revisited in second year or Advanced Placement chemistry.

Questions:
(to be used after the two demonstrations – either discussed orally or written)

1. Write and balance the equations for each of the reactions you observe.

   Answers are provided in the teacher discussion for demonstration #2 above.

2. Predict whether the can demonstration would work using a solution of copper (II) sulfate. How did you arrive at this prediction?

   It would not occur. If you tested the aluminum foil with a copper (II) sulfate, you know that there will be no reaction.

3. If you have covered the activity series with your students, you could ask questions based on the activity series. These questions could include "Will copper replace silver in a single replacement reaction?"

   Yes because copper is more reactive than silver.

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STUDENT WORKSHEETS

Name_____

Demonstration # 2

1. Detailed observations made during the demonstration.

2. What reactions do you think are occurring in the beaker? Why?

3. Write equations for your reaction in questions # 2.

4. Predict whether the can demonstration would work using a solution of copper (II) sulfate. How did you arrive at this prediction?

5. Will copper replace silver in a single replacement reaction?

6. Will silver replace copper in a single replacement reaction?

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TEACHER TIPS

Laboratory Activity:
Teacher Information:

A Simple Electrochemical Cell Based
Based on a Single Replacement Reaction
(Adapted from a minilab from Woodrow Wilson Team 6 Binder)

Purpose: The purpose of this lab is to construct a simple electrochemical cell and measure the voltage produced in the cell.

Introduction: Too often students just accept what the teacher tells them. The use of this laboratory is a way to show students that electrons are actually transferred in single replacement reactions. If electrons are given a conductor through which to travel, they will move from a more reactive metal to a less reactive metal. This is the basis by which batteries operate and while this topic is usually only touched on in a first year chemistry course, it is thoroughly covered in a second year of chemistry, whether at the high school or college level.

Time:
Teacher prep time: 30 minutes
Laboratory time: 30 minutes

Materials:

- copper metal, cut into small pieces (approximately 1 cm by 1 cm)
- zinc metal, cut into small pieces (approximately 1 cm by 1 cm)
- filter paper
- 1.0 M zinc sulfate
- 1.0 M copper (II) sulfate
- 1.0 M potassium nitrate
- Multimeter
- Petri dish
- Dropper pipets

Safety:

- Wear safety goggles and aprons
- Do not get the solutions on your hands, both sulfate solutions are skin irritants
- Copper (II) sulfate is toxic by ingestion or inhalation

Disposal:

The aqueous solutions may be flushed down the drain if the drains are connected to a sanitary sewage system. The solids may be deposited in a solid

waste container. If the drain system does not empty into a treatment facility, landfill the aqueous solutions. Flinn Method #26b and #26a.

Procedure:

1. Cut a rectangular piece of filter paper so that it fits into the petri dish.
2. Place a piece of copper metal and zinc metal onto the filter paper about 3 cm apart.
3. Place two drops of 1 M copper (II) sulfate at the edge of the copper metal.
4. Repeat step 3 with the zinc metal and the zinc sulfate solution.
5. Place two drops of potassium nitrate solution between the two metals. This will serve as the salt bridge.
6. Switch the multimeter to DC volts and turn on. Place the red probe on the copper metal and the black probe on the zinc metal. Record the voltage reading.
7. Reverse the probes in step 6 and record voltage reading.

Questions:
(To be answered by each student)

2. Which of the two metals used, zinc or copper, is more reactive? (zinc)

3. Based on the data that you recorded, in which direction (from zinc to copper or from copper to zinc) do the electrons flow in this electrochemical cell? (from copper to zinc)

3. How did you reach the conclusion given in question 2? (zinc is more reactive than copper which means that zinc will more easily lose its electrons)

4. If you made a cell using the metals magnesium and silver, which way would you predict the electrons would flow? (Mg to Ag)

5. How would you test your prediction from question number 3?
(Set a cell similar to the one used previously using a soluble salt solution of magnesium and a soluble salt solution of silver – probably nitrate salts of both metals. Place a piece of magnesium on the filter paper and add 2 drops of the magnesium solution to the top of the Mg. Do the same with the silver metal and silver solution. Placing the silver metal about 3 cm from the Mg. Place a few drops of potassium nitrate between the two metals. Measure the voltage between the two by placing the red probe on the silver and the black probe on the Mg. If the voltage is positive that means that the electrons do flow from Mg to Ag.)

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Assessment:

1. Write and balance the chemical equation for the reaction of zinc with a solution of silver nitrate.
2. In the aluminum foil and copper (II) chloride demonstrations, in which direction did the electrons flow? (from copper ions to aluminum or from aluminum to copper ions)

REFERENCES

The following cite may be used with your students if you would like for your students to calculate their possible mercury intake.
http://www.gotmercury.org

LESSON FIVE
Concentration!

DEVELOPED BY NORMA ASHBURN

FOCUS

Preparing, diluting and dispensing of solutions are among the most time-consuming and personnel-intensive operations in the chemical laboratory. The research in the HML laboratories generally requires the digestion of the plant and animal samples in specific solution concentrations. Students will prepare and dilute molar solutions while developing a critical skill necessary to perform the research of the scientists at HML. Connections will be made to the work of Steve Christopher and research group in the NIST laboratories.

GRADE LEVEL

Grades 9-12

SUBJECT AREA

Chemistry

FOCUS QUESTION(S)

- What calculations and procedures are necessary to prepare solutions of different molarities and volumes?
- How are solutions of dilute solutions prepared from concentrated solutions?

SOUTH CAROLINA CHEMISTRY STANDARDS

Standard C-1: The student will demonstrate an understanding of how scientific inquiry and technological design, including mathematical analysis, can be used appropriately to pose questions, seek answers, and develop solutions.

C-1.1 Apply established rules for significant digits, both in reading a scientific instrument and in calculating a derived quantity from measurement.

C-1.2 Use appropriate laboratory apparatuses, technology, and techniques safely and accurately when conducting a scientific investigation.

C-1.3 Use scientific instruments to record measurement data in appropriate metric units that reflect the precision and accuracy of each particular instrument.

C-1.8 Use appropriate safety procedures when conducting investigations.

Standard C-6: The student will demonstrate an understanding of the nature and properties of various types of chemical solutions.

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C-6.4 Carry out calculations to find the concentration of solutions in terms of molarity and percent weight (mass).

Ocean Literacy: Essential Principles and Fundamental Concepts

6: The oceans and humans are inextricably interconnected.

e. Humans affect the oceans in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (point source, non-point source, and noise pollution) and physical modifications (changes to beaches, shores and rivers). In addition, humans have removed most of the large vertebrates from the ocean.

APPROXIMATE TIME

90 minutes

MATERIALS

Per Lab Group:

- Electronic balance, weighing paper, and weighing vessels
- Graduated cylinder, Volumetric flasks, and Erlenmeyer flasks
- Variety of glassware from 1000 mL, 500 mL, 250 mL, and 100 mL with rubber or
- Glass stoppers as required.
- Beakers: variety of glass beakers from 1000 mL, 600 mL, 400 mL, 250 mL, and 150 mL.
- Hot plate
- Containers: a variety of laboratory containers and vials with lids or stoppers to contain
- Prepared solutions.
- General safety equipment.
- Chemicals, solids and liquids, to prepare specified solutions.
- Distilled water

BACKGROUND INFORMATION

Lab experiments and types of research often require preparation of chemical solutions in their procedure. Many experiments involving chemicals call for their use in solution form, that is, two or more substances are mixed together in known quantities. This may involve weighing a precise amount of dry material or measuring a precise amount of liquid. Preparing solutions accurately will improve an experiment's safety and chances for success.

Molar solutions are the most useful in chemical reaction calculations because they directly relate the moles of solute to the volume of solution. **Molarity** (M) means the

number of moles of solute per liter of solution. To prepare a 1 M solution, slowly add 1 g formula weight of compound to 500-mL distilled or deionized water in a 1000-mL volumetric flask half filled with distilled or deionized water. Allow the compound to dissolve completely, swirling the flask gently if necessary. Once the solute is completely dissolved and the solution is at room temperature, dilute to the mark with water. Invert the flask several times to mix.

Preparing, diluting, and dispensing of solutions are among the most time-consuming and personnel-intensive operations in the chemical laboratory. Sample preparation is the major limiting factor for sample throughput and productivity. The research in the labs at HML generally requires the digestion of the plant and animal samples. Also the analysis and purification technologies require the samples to be in solution. For chromatography work, TLC (thin layer), HPLC (high pressure liquid) and gas chromatography the samples are introduced in solution. Another technology that is highly employed in ocean research is the mass spectrometer. Again, the sample is prepared in solution and converted to a gas by the intense heat of an argon torch.

NIST has a lead role in the quality assurance (QA) of measurements of organic and inorganic contaminants in marine mammals. NIST fulfills this role by providing control materials and reference materials, coordinating interlaboratory comparison exercises.

The skill of solution preparation is a critical one and many who seek positions in chemical laboratories are inadequately prepared. Being skilled in this technique affords opportunities to enter the chemical job market. In order to provide control and reference solutions NIST researchers must be especially skilled in this procedure.

These are key words:

- **Solute** - The substance which dissolves in a solution
- **Solvent** - The substance which dissolves another to form a solution. For example, in a sugar and water solution, water is the solvent; sugar is the solute.
- **Solution** - A mixture of two or more pure substances. In a solution one pure substance is dissolved in another pure substance homogenously. For example, in a sugar and water solution, the solution has the same concentration throughout, ie. it is homogenous.
- **Mole** - A fundamental unit of mass (like a "dozen" to a baker) used by chemists. This term refers to a large number of elementary particles (atoms, molecules, ions, electrons, etc) of any substance. 1 mole is 6.02×10^{23} molecules of that substance. (Avogadro's number).M

TEACHER TIPS

Decide which and how much of each solution will be needed for the school term and make assignments to each group.

Teacher Notes:

The following topics should be discussed and demonstrated. Those items marked with an asterisk (*) are prerequisites to the practice sessions.

* Location of mass data for elements on the Periodic Table of Elements
* Calculation of molar mass for a given chemical solid: sodium chloride (NaCl), glucose ($C_6H_{12}O_6$), copper (II) sulfate ($CuSO_4$), etc.
* Calculating the number of moles in a given mass and mass in a given number of moles.
*Understand the proper formulas for molar solution calculations.

Molarity (M) = Number of Moles of Solute
Solution Volume (Liter/s)

Mass of Solute = Solution Volume (Liter/s) x Molarity x Molar Mass

Molarity (Mc) x Volume (Vc) = Molarity (Md) x Volume (Vd)

Mc = molarity of concentrated solution
Vc = Liters of concentrated solution
Md = molarity of diluted solution
Vd = Liters of diluted solution

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The following table includes many of the chemicals that are used as solutions in a high school chemistry course.

Compound	**Formula**	**g/mole**
Aluminum nitrate	$Al(NO_3)_3.9H_2O$	375.13
Aluminum sulfate	$Al_2(SO_4)_3.18H_2O$	666.42
Ammonium chloride	NH_4Cl	53.49
Ammonium carbonate	$(NH_4)_2CO_3$	96.09
Barium chloride	$BaCl_2.2H_2O$	244.28
Barium nitrate	$Ba(NO_3)_2$	261.35
Calcium nitrate	$Ca(NO_3)_2.4H_2O$	236.16
Cobalt (II) chloride	$CoCl_2 . 6H_2O$	237.95
Cobalt (II) nitrate	$Co(NO_3)_2.6H_2O$	291.05
Copper (II) chloride	$CuCl_2 . 2H_2O$	170.49
Copper (II) nitrate	$Cu(NO_3)_2$	241.60
Copper (II) sulfate	$CuSO_4. 5H_2O$	249.69
Iron(II) chloride	$FeCl_2.4H_2O$	198.81
Iron(II) sulfate	$FeSO_4.7H_2O$	278.03
Iron(III) chloride	$FeCl_3.6H_2O$	270.32
Lead (II) acetate	$Pb(C_2H_3O_2)_2.3H_2O$	379.34
Lead (II) nitrate	$Pb(NO_3)_2$	331.20
Lithium chloride	$LiCl$	42.40
Lithium nitrate	$LiNO_3$	68.95
Magnesium nitrate	$Mg(NO_3)_2.6H_2O$	256.43
Magnesium sulfate	$MgSO_4.7H_2O$	246.50
Nickel nitrate	$Ni(NO_3)_2.6H_2O$	290.82
Potassium Chloride	KCl	74.56
Potassium carbonate	K_2CO_3	138.21
Potassium iodide	KI	166.01
Potassium nitrate	KNO_3	101.11
Potassium permanganate	$KMnO_4$	158.04
Potassium sulfate	K_2SO_4	174.27
Sodium chloride	$NaCl$	58.45
Sodium carbonate	Na_2CO_3	105.99
Sodium hydroxide	$NaOH$	40.00
Sodium nitrate	$NaNO_3$	84.99
Sodium phosphate	$Na_3PO_4.12H_2O$	380.12
Sodium sulfate	$Na_2SO_4.10H_2O$	322.19
Strontium chloride	$SrCl_2.6H_2O$	266.64
Strontium nitrate	$Sr(NO_3)_2$	211.63
Zinc nitrate	$Zn(NO_3)2.6H_2O$	297.49

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OTHER RESOURCES

Web Resources:

http://www.carolina.com/chemistry/resources/solution_preparation.asp
This site provides instructions for preparing several types of solutions, molar, % mass, dilution and normal.
http://www.graphpad.com/quickcalcs/Molarityform.cfmHere is a calculator to determine mass, volume or molarity.
http://water.me.vccs.edu/courses/ENV211/lesson8_3.htm
There is a great math lesson on concentration here!
http://www.saskschools.ca/curr_content/chem30_05/4_solutions/teacher/solutions_teacher_index.htm
Go here for a good set of practice problems.
http://www.uab.edu/clabsc/solution.htm#molar
Another good site for practice problems on molarity and dilution
http://www.woodrow.org/teachers/esi/2002/Biology/Projects/lab_skills/ls8/
A good presentation on serial dilutions
http://www.nist.gov/public_affairs/factsheet/NIST_Did_you_know.htm
A great site explaining facts about NIST, National Institute of Standards and Technology

ASSESSMENT

1. You are to make a list by name and size, as applicable, of all the laboratory equipment to be used in making a molar solution.

Name	Size

2. You are to list the criteria for the calculations required to make a 0.25 molar solution of $Ca(NO_3)_2.4H_2O$ with a volume of 1.50 L.

3. You are to write out the steps of the procedure that are required to actually produce a molar solution.

4. You have 1 L of a 0.125 M aqueous solution of table sugar. You want to dilute the solution to 0.05 M. What do you do?

Assessment Answers:

1. You are to make a list by name and size, as applicable, of all the laboratory equipment to be used in making a molar solution.

Name	Size
Centigram balance	NA
Weighing paper	
Volumetric Flask	1000 mL
Distilled water	at least 1000mL
Periodic table	
Calculator	
Chemical	
Spatula or spoon	

2. You are to list the criteria for the calculations required to make a 0.25 molar solution of $Ca(NO_3)_2.4H_2O$ with a volume of 1.50 L.

Determine the formula mass of the compound. (236.16grams). Use the atomic masses from the periodic table.

Determine the number of moles needed for preparing the solution. (0.375moles). (Molarity)(Volume) = moles

Determine the number of grams of compound needed. (88.56 g) Grams = (# of moles)(formula mass).

3. You are to write out the steps of the procedure that are required to actually produce a molar solution.

Determine the formula mass of the compound. Use the atomic masses from the periodic table.

Determine the number of grams of compound needed. Grams = (1mole)(formula mass).

Mass the solute.
Add the solid to a 1.00L volumetric flask.

Add enough distilled water to fill to line.

Label as 1.0 M ____.

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4. Using the equation, $V_cM_c = V_dM_d$, you determine that the volume of the diluted solution should be 2.5 L. So we simply add enough water to the first solution so that the solution's volume becomes 2.5 L.

STUDENT PROCEDURE

Part 1

MOLAR SOLUTION CALCULATIONS

This exercise to designed to increase your confidence in calculating the number of moles and mass of solute required to prepare a specific molar solution and then to obtain the required mass using the proper laboratory equipment..

STEP 1

Determine the molar mass of the following elements and chemicals. Show all calculations as required.

1. Silver nitrate, $AgNO_3(s)$ _____g/mol
2. Ammonia, $NH_3(l)$ _____g/mol
3. Barium chloride, $BaCl_2(s)$ _____g/mol
4. Magnesium nitrate, $Mg(NO_3)_2(s)$ _____g/mol

STEP 2

Obtain the necessary laboratory equipment to determine the mass of sodium chloride,
NaCl, to prepare 1.00 L of a 1.00 M solution. Calculate the molar mass of sodium chloride, the number of moles of this solute in the required volume, and the mass of sodium chloride needed.
Record calculations in the data table.

STEP 3

Using the balance measure the amount of sodium chloride calculated in STEP 2. Using the balance, determine the mass of the weighing paper, mass of weighing paper + sodium chloride, and then calculate the mass of sodium chloride.
Record the completed data in the following data table.

STEP 4

Compare your results to the label and record in data table.
If so, congratulate yourself. If not, check for possible calculation and mass errors.

STEP 5

Clean and return all laboratory equipment and chemicals.

Part 2

Molar Solution Preparation

Your instructor will give you the chemical formula for a compound. Your task is to determine the molar mass to the nearest 0.01 g, calculate the number of moles and mass required to prepare 1.00 L of a 1.0 M solution using this compound, and to

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measure the amount of solute required. Completing Part 2 with reasonable accuracy will receive the Instructor's Verification for the Part 2
Complete the following table by performing the calculations and measurements.

PART 3

Preparation of a Dilute Solution
STEP 1
You will use your stock 1.0 M solution to make a more dilute solution. The stock solution will be used to prepare 250 mL of a 0.20 M solution.
STEP 2
Calculate the volume of the 1.0 M stock solution to be used to prepare the 250 mL of 0.20M solution. Calculating and measuring the proper amount of 1.0 M _____to prepare the 0.20 M _____ solution correctly, your instructor will sign below.
Complete the data table by performing the calculations and measurements.
Show all calculations.
Instructor

Data
Part 1

MOLAR SOLUTION CALCULATIONS
Step 1

1. Silver nitrate, $AgNO_3(s)$ _____g/mol
2. Ammonia, $NH_3(l)$ _____g/mol
3. Barium chloride, $BaCl_2(s)$ _____g/mol
4. Magnesium, $Mg(NO_3)_2(s)$ _____g/mol

Step 2
Calculate the molar mass of sodium chloride. _____g/mol
Calculate the number of moles of sodium chloride in the given solution
._____mol
Calculate the mass of sodium chloride required for this solution.
_____g

Step 3

1. Mass of weighing paper=_____g
2. Mass of sodium chloride + weighing paper=_____g
3. Mass of sodium chloride=_____g

Step 4

1. Do the molar masses calculated in STEP 1 agree with the molar masses for these chemicals in the FLINN catalog (Check with teacher or see catalog.)

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Calculated mass _____ Actual mass _____

2. Does the amount of sodium chloride calculated in STEP 2 agree with the amount of sodium chloride measured in STEP 3?
Calculated mass _____ Measured mass _____

Part 2

Molar Solution Preparation

Show all calculations.
Chemical _____ g/mol _____
Number of moles _____
Solute _____g
Measurement
1. Mass of weighing paper=_____g
2. Mass of (chemical) + weighing paper=_____g
3. Mass of (chemical)=_____g
Instructor Verification
_____has successfully completed **PART 2** of this exercise.
_____Instructor

Part 3

Preparation of a Dilute Solution

Volume of 1.0 M solution required _____L
Volume of solvent to be added _____L
Errors must be corrected to receive your Instructor's Verification
Instructor Verification
_____has successfully completed **PART 3** of this exercise
_____

LESSON SIX
Gutless Chromatography

DEVELOPED BY CONNIE LEVERETT

FOCUS

Different types of chromatography, thin layer and gas, are frequently used by scientists to isolate and extract different chemicals in mixtures. Students will conduct thin layer chromatography to separate different types of plant pigments, polar and nonpolar. Students will be introduced to the chemical principles inherent in chromatography technique with an emphasis on the solubility principles involved in this technique.

GRADE LEVEL

Grades 9-12

SUBJECT AREA

Chemistry or Biology

FOCUS QUESTION(S)

- Which solvent has the greatest solubility to plant pigments and therefore separates the greater number of pigments in land plants?

SOUTH CAROLINA CHEMISTRY STANDARDS

Standard C-6: The student will demonstrate an understanding of the nature and properties of various types of chemical solutions.

C-6.2 Compare solubility of various substances in different solvents (including polar and nonpolar solvents and organic and inorganic substances).

C-6.11 Use a variety of procedures for separating mixtures (including distillation, crystallization filtration, paper chromatography, and centrifuge).

Ocean Literacy: Essential Principles and Fundamental Concepts

6: The ocean and humans are inextricably interconnected.

e. Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (point source, non-point source, and noise pollution) and physical modifications (changes to beaches, shores and rivers). In addition, humans have removed most of the large vertebrates from the ocean.

APPROXIMATE TIME

1 class period

MATERIALS

Per Lab Group:

(these may vary depending on the structuring of the lab tasks)

- 2 silica thin layer chromatography (TLC) sheets
- Petroleum ether
- Acetone
- cm rulers
- leaf from land plant (recommendation: magnolia tree)
- 2-400 mL beakers
- graduated cylinder
- coin (quarter is best!)

Safety:

- Wear safety goggles, gloves and aprons

BACKGROUND INFORMATION

Chromatography is a wonderful tool for scientists who are isolating compounds from mixtures. Isolation occurs because molecules are separated based on their polar and nonpolar characteristics or their solubility in different solutions. Chromatography comes from Greek: “chroma” means color and “graphein” means writing. In all chromatographic techniques there is a solid phase and a moving phase. In paper chromatography the solid phase is the paper and the moving phase is a liquid. Liquids may be either water for moving polar solutes or organic solvents for moving organic solutes. In thin layer chromatography, alumina and silica are frequently used as the solid phase either on a glass plate or as a layer on an aluminum or plastic sheet. Organic solvents are used as the moving phase. In gas chromatography, the mobile phase is a gas and the stationary phase is a liquid inside a column. Column chromatography uses a solid phase in a tube with a liquid as the moving phase.

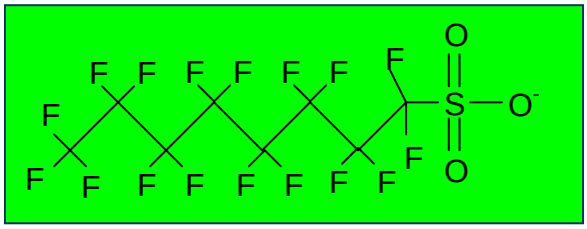
Although high school biology and chemistry courses frequently use paper chromatography to illustrate this technique, scientists frequently use thin layer chromatography (TLC) and gas chromatography. The type of chromatography used depends on the compound being isolated. Dr. Mikhail S. Tswett (Tsvet) was the first scientist to develop chromatography technique. He was a Russian botanist studying plant pigments.

At the Hollings Marine Lab scientists use a variety of chromatographic techniques. Dr. Yelena Sapozhnikova at the Hollings Marine Lab developed a thin layer

chromatography technique in her dissertation to separate pesticides from lipids in fish. She currently uses column chromatography to extract antifouling biocides from recreational marinas. Dr. Peter Moeller uses thin layer chromatography to extract pigments from phytoplankton. Dr. Jenn Keller uses chromatography to separate PFOS and PFCs from plasma proteins in turtles. In this experiment, thin layer chromatography is highlighted.

Silica Thin Layer Chromatography (TLC) sheets are used to separate plant pigments from tree leaves. The TLC sheets are the solid phase and the petroleum ether and acetone solvent are the moving phase. Petroleum ether is organic and nonpolar. It attracts the nonpolar pigments or nonpolar molecular sites of pigments in the leaves. Acetone attracts both the polar and nonpolar pigments because it has both polar and nonpolar parts of the molecule. Density plays a role as well with lower density molecules moving further than higher density molecules. The increased separation of pigments with acetone occurs because the acetone interacts with the polar charged areas of the pigments and moves them along to further separate the different pigments. The silica provides the adhesive solid phase for the pigments as they are moved along by the moving solvents.

Dr. Jenn Keller of Hollings Marine Lab takes samples of turtle blood from field studies to study the concentrations of PFCs and PFOS. PFCs are perfluorinated chemicals. PFOS are perfluorooctane sulfonates.



PFC's are manmade. Dr. Keller's research findings "suggest that bioaccumulation of PFCs in sea turtles is influenced by species, age, and habitat." PFOS are present in Scotchgard® and Teflon®. The turtle blood samples are treated and run through chromatography columns in order to isolate and extract the PFOS. The PFOS are neutralized and added to a wax column. Then the PFOS are treated first with formic acid and then with ammonium hydroxide to move the PFOS through the column and isolate them. She basically (tongue in cheek!) used changes in pH to change the solubility of the PFOS in order to isolate them during the extraction. After they are isolated, they are run through a mass spectrophotometer to identify their chemical structure.

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TEACHER TIPS

To grab student attention, play some Live Earth videos or music. Ask students what the function of this concert was? Live Earth was produced in order to increase environmental awareness.

Other than prepping each group of materials for the laboratory, the solvent needs to be made. Students can make the solution the day before or at the beginning of the lab if you want them to have more practice with % solution chemistry. An optimal solution is 70% petroleum ether and 30% acetone. For 100 mL, 70 mL of petroleum ether and 30 mL of acetone would be combined. Lab groups can share solvents since 100 mL will more than one lab group will need or students can hold the cm ruler along the 400 mL beaker fill the beaker with water to that level, empty the water into the graduated cylinder, and make a percent solution for that volume of solvent.

Example: 30 mL of solvent
30 X .7 = 21 mL of petroleum ether
30 X .3 = 9 mL of acetone
Double check: 21 + 9 = 30 and 21/30 x 100 = 70%

To compare the effectiveness of different solubilities, two TLC sheets can be run per lab group with one TLC chamber of petroleum ether and the other using petroleum ether and acetone. You may add more variations if you have the equipment and the time or have students experiment with different % compositions of these solvents.

Fisher has 200 Silica Gel TLC sheets for $216.00. Fisher offers a South Carolina discount to schools and this price does not include the discount.

If you are unable to purchase TLC be sure to do a paper chromatography using Whatman chromatography paper or coffee filter paper. Or if you want to make a connection to what students do in biology and scaffold their understanding to chemistry with a constructivist approach, have students do both paper chromatography and TLC. The experimental variable would be the different the solid phases. Some formative questions are: Comparing the paper chromatograph with the TLC chromatograph, which is more high tech? Which gave better results? Which technique, paper or TLC, would you use if you were a research chemist and why?

Further Investigation Suggestions: Have students run a TLC with different solvents or different solvent concentrations. For example, hexane gives a single separation of primarily xanothophylls. Students could do TLC with different concentrations of hexane and acetone versus petroleum ether and acetone.

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Caution: See Flinn for disposal of petroleum ether (#18b). In small volumes, it can be evaporated in the fume hood with supervision. Be sure to caution students that petroleum ether and acetone are flammable.

REFERENCES

Chromatography lab
http://www.geocities.com/CapeCanaveral/Hall/1410/lab-B-02.html
Cool explanation of fluorescence in plant pigments
http://www.science-projects.com/Photonics.htm
National Standards Activity
http://www.coexploration.org/bbsr/classroombats/html/body_plant_pigments.html
High performance chromatography
http://www.waters.com/WatersDivision/ContentD.asp?watersit=JDRS-5LTGBH
Presentations by Yelena and Peter at Chemistry Writing Workshop—July 9, 2007

Grape Soda Column Chromatography. Flinn Scientific, Inc. Vol. 98-3 Flinn Fax

ASSESSMENT

Formative Assessment: Answers to the lab questions

STUDENT PROCEDURE

1. Place two pieces of a silica thin layer chromatography (TLC) sheet on the lab top with the white silica facing up.
2. Place a cm ruler beside the TLC sheet. Place the widest part of the magnolia leaf (or other type of leaf) 1 cm above the bottom of one sheet. Be sure the shiny top of the leaf is facing up. The dull underside of the leaf should be touching your silica TLC sheet.
3. Use a quarter to make a line of magnolia leaf pigment 1 cm from the bottom by rubbing the quarter across the top of the leaf. **Caution:** Be firm, but gentle! It is easy to rub off the thin layer of silica with your quarter. If you rub off a little of the silica but still have a good line of olive green pigment, your chromatography will be successful.
4. Pour petroleum ether and acetone (7:3) solvent in the bottom of a 400 mL beaker up to but below 1 cm by holding the cm ruler beside the beaker as you pour. Pour petroleum ether in another beaker.
5. Place one treated TLC sheet in one beaker and the other TLC sheet in another. Place the watch glass over the beaker. The eluting solvent (petroleum ether and acetone) will begin running up the TLC sheet. What is happening to the original line of pigment from the leaf?
6. Allow the eluting solvent to run until it is 1 cm from the top of the TLC sheet.
7. Pull the TLC sheet out of the eluting solvent to stop the chromatography.
8. Which solvent was the most effective in creating five pigment lines above the original line on your chromatogram? Notice that #1 on the table is the first pigment above the original pigment sample on the sheet. Pigment #5 is the one at the top of the chromatogram. Using your cm ruler measure the distance from the original pigment line (looks brown for magnolia leaves) of each of the pigments you see. Record the distance of each pigment from the original pigment line in the data table.
9. Each pigment has an Rf value, the speed at which it moves over the paper compared with the speed of the solvent. Calculate and record the Rf values of each pigment. Rf = Distance moved by the pigment / Distance moved by the solvent.
10. Record the colors of each pigment line beside the numbers in the table. Try to distinguish between colors using adjectives like blue-green or olive-green when possible. If the yellows look the same, record yellow for more than one number. The yellow-orange pigments are carotenes, yellow pigments are xanthophylls, and green pigments are chlorophylls.
11. Measure and record the total distance the eluting solvent moved on the TLC sheet. Is each of these lines a different pigment? Substantiate your answer with at least one reason.
12. Answer the remaining questions on the student worksheet.

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Chromatography Student Lab Data And Questions

Name(s):_____

Type of Leaf: _____
Type of Chromatography: _____
Solid Phase: _____

Petroleum (100%) DATA TABLE:

Pigments (#5 is at the top of the TLC sheet)	Distance traveled	Rf Value	Colors	Name of Pigment Group
5.				
4.				
3.				
2.				
1.				

Moving Phase: _____
Eluting Solvent including percentages:
_____

Distance Traveled by the solvent: _____

Petroleum/acetone (7:3) DATA TABLE:

Pigments (#5 is at the top of the TLC sheet)	Distance traveled	Rf Value	Colors	Name of Pigment Group
5.				
4.				
3.				
2.				
1.				

Moving Phase: _____

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Eluting Solvent including percentages:

_____

Distance Traveled by the solvent: _____

Questions:

1. Based on the distance traveled and Rf values of each pigment, which pigments had a greater density?
2. Which TLC had the most separation of pigments? Please explain why.
3. You are a chemist trying to isolate a harmful chemical that is polar from the tissues in an oyster, devise a technique based on your lab procedure to achieve this separation.

Optional enrichment:
Answer questions after viewing the video on the following web page:

http://www.uniregensburg.de/Fakultaeten/nat_Fak_IV/Organische_Chemie/Didaktik/Keusch/D-CC-e.htm

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LESSON SEVEN
Fish Gut Chromatography

DEVELOPED BY CONNIE LEVERETT

FOCUS
Students will compare thin layer and column chromatography to separate chemical compounds of different properties in fish extracts. After running the chromatography, students will identify fluorescent compounds using the UV lamp.

GRADE LEVEL
Grades 9-12

SUBJECT AREA
Chemistry

FOCUS QUESTION(S)
- How can different organic compounds be separated using chromatography?
- Which is the best tool for separation: thin layer or column chromatography?
- What kind of environmental research relies on chromatography as a research tool?

SOUTH CAROLINA CHEMISTRY STANDARDS
Standard C-6: The student will demonstrate an understanding of the nature and properties of various types of chemical solutions.

C-6.2 Compare solubility of various substances in different solvents (including polar and nonpolar solvents and organic and inorganic substances).

C-6.11 Use a variety of procedures for separating mixtures (including distillation, crystallization filtration, paper chromatography, and centrifuge).

Ocean Literacy: Essential Principles and Fundamental Concepts

6: The ocean and humans are inextricably interconnected.

e. Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (point source, non-point source, and noise pollution) and physical modifications (changes to beaches, shores and rivers). In addition, humans have removed most of the large vertebrates from the ocean.

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APPROXIMATE TIME

45 minute Preparation of fish tissues
60 minute TLC and Column Chromatography Lab

MATERIALS

Per Lab Group:

Part 1

- Sodium sulfate
- hexane
- 3 - 250 mL or 500 mL Erlenmeyer flasks and stoppers
- Centigram balance
- Fish (any fish will do, but the fish should not be too skinny!)
- Knife or dissecting scissors and scapula for dissecting or cutting up the fish (can be done at home)
- Stirring rods
- graduated cylinder
- aluminum foil
- mortar and pestle
- Large test tubes
- Fume hood for concentrating solution

Part 2

Thin Layer:

- 1 silica thin layer chromatography (TLC) sheet
- cm rulers
- 8 ml hexane/2 ml acetone or enough of this solvent ratio to cover bottom of beaker
- 400 mL or 600 mL beakers with watch glass covers
- 3 micropipettes
- UV light lamp
- Fume hood

Column:

- Buret or Any tubing that can be packed with alumina and Na_2SO_4 and has stopcock capabilities
- ring stand
- clamp
- erlenmeyer
- 10 g alumina
- 2 g Na_2SO_4
- 80 ml hexane and 20 mL acetone mixed in a solution
- UV light lamp

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Loose aluminum hydroxide thin layer chromatography:

- 10 g Alumina (aluminum hydroxide)
- 7 cm x 11 cm glass plate (dimensions are approximate)
- graduated pipette
- Thin Layer Chromatography chamber (flat bowl that can hold glass plate and a prop like an evaporating dish to lean the plate on)
- cover for chamber or bowl
- Fume hood
- 3 micropipettes

Safety:

- Wear safety goggles, gloves and aprons

BACKGROUND INFORMATION

Chromatography is a wonderful tool for scientists who are isolating compounds from mixtures. Isolation occurs because molecules are separated based on their polar and nonpolar characteristics. Chromatography comes from Greek: "chroma" meaning color and "graphein" meaning writing. In all chromatographic techniques there is a solid phase and a mobile phase. In paper chromatography the solid phase is the paper and the moving phase is a liquid. Liquids may be either water for moving polar solutes or organic solvents for moving organic solutes. In thin layer chromatography, alumina and silica are frequently used as the solid phase either on a glass plate or as a layer on an aluminum or plastic sheet. Organic solvents are used as the moving phase. In gas chromatography, the mobile phase is a gas and the stationary phase is a liquid inside a column. Column chromatography uses a solid phase in a tube with a liquid as the moving phase.

Although high school biology and chemistry courses frequently use paper chromatography to illustrate this technique, scientists frequently use thin layer chromatography (TLC) and gas chromatography. The type of chromatography used depends on the compound being isolated. At the Hollings Marine Lab scientists use a variety of chromatography techniques. Dr. Yelena Sapozhnikova at the Hollings Marine Lab uses column chromatography to extract antifouling biocides from water samples at recreational marinas. Dr. Peter Moeller uses thin layer chromatography to extract pigments from harmful phytoplankton.

In this experiment, students will compare three chromatography techniques to illustrate the usefulness of chromatography and to identify why scientists use different techniques. These different techniques are based on the chemical properties of the substances being extracted and the amounts of the substances

being analyzed. Column chromatography was invented by a Russian botanist, Mikhail S.Tswett (Tsvet) in the 1900's to study plant pigments.

Polycyclic aromatic hydrocarbons (PAH's) are produced through combustion of fuels. There are number of different types and they have unique fluorescent indicators. The EPA has standards for these in our air and water.

Please refer to the following web sites for information on these chemicals:

http://www.atsdr.cdc.gov/toxprofiles/phs69.html

http://en.wikipedia.org/wiki/Polycyclic_aromatic_hydrocarbon

TEACHER TIPS

1. Students will watch the video of Dr. Yelena Sapozhinikova on-line or you can show it a projector from your laptop.
2. The basic types of tissues that students will retrieve will be liver and heart that are often deep red with variations for liver. Although liver has much more fat or lipid content than heart tissue, the color scheme idea is easier for students who do not know anatomy.
3. If you really hate fish guts, here are some suggestions: get one of your students to donate the fish already filleted in Ziplocks, ask the marine science or biology teacher to supply you with these materials after a dissection, ask the fish market ahead of time to supply you with these materials. The fish market usually fillets the fish as soon as they get them and your grocery store usually gets filleted fish.
4. The greater the quantity of the tissue you process, the greater the concentration of the organic molecules collected and the better the chromatography results. The ratio of sample to Na_2SO_4 depends on whether the sample is completely ground or digested by the combination of the grit of the Na_2SO_4 and the mortar and pestle. If the sample is not ground up enough due to lack of "grit", add more Na_2SO_4. The muscle will be very hard to grind completely. If you have a blender to make a community sample of muscle, use that instead for the muscle. In the original lab procedure, I used 5 g of liver/heart, and approximately 25 g of muscle and 25 g of pyloric caeca/stomach/intestine. The muscle required about four more grams of Na_2SO_4.
5. Hexane requires special disposal procedures. Do not rinse it down the drain. Usually the small quantities in a lab can be evaporated in a hood. Make sure you monitor this process.

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6. The quantity of hexane depends on the mass of the samples. The ratio I used was sample to hexane, 2:1. But a visual aid is that when all the Na_2SO_4 is covered with the solvent, there is enough hexane to dissolve the organic molecules from the sample.
7. If you have the equipment to evaporate the hexane more rapidly, please be sure to follow **safety procedures**. Hexane is a hazardous flammable chemical and is a respiratory irritant. Hexane's boiling point is 69°C.

Day 2

*1. All types of chromatography are instrumental in isolating different chemicals in solutions or mixtures. Decide if you want students to do all three assays or if you want them to choose the best technique for their purpose with the result that some student lab groups will do different tests and compare.

2. The only sample that will not be yellow is the muscle or white sample. You may want to skip this sample in the chromatography since it doesn't show any lipid concentration or run it to be consistent.

3. Topping off the column with Na_2SO_4 ensures that any water will be absorbed rather than diluting the sample.

OTHER RESOURCES

Web Resources:

http://www.uniregensburg.de/Fakultaeten/nat_Fak_IV/Organische_Chemie/Didaktik/Keusch/D-CC-e.htm

http://www.atsdr.cdc.gov/toxprofiles/phs69.html

http://en.wikipedia.org/wiki/Polycyclic_aromatic_hydrocarbon

ASSESSMENT

See separate sheet after Student Procedure.

Answers to assessment:

1. Sodium sulfate absorbs water and is also a good gritty substance for grinding tissues. It absorbs the water that could dilute the results of the column chromatography.
2. Almost all environmental researchers use chromatography of some sort to isolate the chemicals they are researching and check to see what the

concentration levels are or isolate the types of chemicals that may be causing problems in the environment.

3. Lots of labs may be used in this answer to include the Hollings Marine Lab, Grice Marine Lab, and Environmental Protection Agency. See web site from EPA.
4. Yes. The results vary with wide bands of pink fluorescence from the column and microdots of blue fluorescence on the TLC sheets.
5. This question is meant to make students realize that different techniques are utilized for different purposes: the column could collect the chemicals in a liquid form, but the TLC sheets would allow isolation on a solid and then the chemicals isolated would have to be put in a solvent. Scientists utilize the technique that is best for their research.

STUDENT PROCEDURE

Name_____

Day 1

Safety: Hexane is a hazardous flammable chemical. No flames! Use the stoppers and the hood for pouring hexane and evaporating. Do not pour it down the drain. Ask your teacher how to discard it.

1. Why are you doing this lab? Watch the video of Dr. Yelena Sapozhnikova to determine what your purpose is. Write down your question for this lab. Write a corresponding hypothesis for the question. Read the rest of the procedure and determine if this procedure matches your hypothesis and if any modifications need to be made. Consult with your teacher.

2. Dissect or cut up fish into tissues/organs that are categorized by three basic colors: white, red, and lighter red/yellow.

3. Separate these tissues on three pieces of aluminum foil.

4. Obtain three 250 mL or 500 mL Erlenmeyer flasks and stoppers and label them with masking tape and permanent markers for the basic tissues/organs that are present in the three samples. Fill in the data table.

5. Mass the mortar. Zero or tare the balance. Add 10 g of Na_2SO_4 and tare the mortar, again. Add the sample and record the mass of the sample. More Na_2SO_4 will need to be added to the white or muscle sample. It will never have the small particle size of the other two samples!

6. Take the sample off the balance and grind the sample. Add it to the Erlenmeyer labeled for this sample.

7. Repeat steps 4 and 5 for the other two samples.

8. Add 50 mL hexane and stopper each sample and swirl the samples until all the Na_2SO_4 is covered. Add more hexane at 5 mL increments until the Na_2SO_4 is covered . The white sample will not grind up as well as the other samples did.

9. Set up three 50 mL test tubes in a test tube rack. Label each test tube with identical labels to the Erlenmeyers. Be sure to put your initials on the labels.

10. Decant the liquid solution of the sample into a test tube. Place the test

tubes under a hood for evaporation of the hexane in order to concentrate the solution.

Fish Gut Samples	Colors of tissue/organs	Overall tissue types or organs present	Mass of sample	Colors of decanted liquids	Majority Lipids or proteins?
1.					
2.					
3.					

Day 2

1. Check extracts under the hood. Extracts will be concentrated at 4-5 mL.

2. Did any of the samples change colors? Why?

3. Below is a list of possible chromatographic set-ups and materials for running the samples. Your teacher will give you directions for using the set-ups.*

4. Chromatographic set-up choices:

- ***Silica Thin Layer Chromatography (TLC) sheets***: Pour 80% hexane/20% acetone solvent in the bottom of a 400 mL beaker up to but below 1 cm by holding the cm ruler beside the beaker as you pour. Using a micropipette, place small drops of concentrated sample along a lightly drawn pencil line that is 1 cm above the bottom of the sheet. The alumina or silica on the TLC sheets will come off easily and you may want to skip the pencil line and put your cm ruler along the edge of the TLC sheet instead! Place the treated TLC sheet in the beaker and place the watch glass over the beaker. The eluting solvent (hexane) will begin running up the TLC sheet. Allow the eluting solvent to run until it is 1 cm from the top of the TLC sheet. Pull the TLC sheet out of the eluting solvent to stop the chromatography. Measure the distances of all layers and the distance of the solvent to calculate Rf values. Place the sample in the dark while using the UV lamp. Look for pink fluorescence along the bottom of the sample and very small dots of blue fluorescence at the top of the lipid curve. These are fluorescent compounds

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(examples) that are also isolated on the chromatograph. Compare your chromatograph with other chromatography tools of classmates. Allow it to dry under the hood (put your initials on the back with a permanent marker!).

- Set up a ***column for chromatography***. View the video on-line from the following web page to show a column chromatography running with plant pigments:
- http://www.uniregensburg.de/Fakultaeten/nat_Fak_IV/Organische_Chemie/Didaktik/Keusch/D-CC-e.htm
- Attach a buret to a ring stand with a clamp. Put an Erlenmeyer under the stopcock to catch any fluids. Pour about 10 g of alumina into the buret and top off the alumina with 1-2 g of Na_2SO_4. Pour 40 mL of hexane into the column to condition it. This allows the experimental sample to run rather than being absorbed into the alumina and not separating. Add the sample by pouring it into the column. You will want to choose one of your yellow samples to run. Pour small amounts of 80% hexane and 20% acetone solvent into the column until the lipids and proteins in the sample separate. This is done by opening the stopcock, pouring 10-20 mL of solvent, letting the excess fluid in the column run into the Erlenmeyer and then shutting the stopcock. Do this until you see different layers of organic chemicals which are the different layers of lipids and proteins. Shine the UV lamp on the column by moving the lamp up and down the column. Place the sample in the dark while using the UV lamp. Look for pink fluorescence along the bottom fourth of the sample and very small dots of blue fluorescence. These are fluorescent compounds (examples: some lipids, polycyclic aromatic compounds and others) that are also isolated on the chromatograph. Compare your chromatograph with other chromatography tools of classmates.

Loose alumina thin layer chromatography. **Safety! Alumina is a hazardous dust that should be used under a hood.** Using a glass plate with dimensions of approximately 7 cm x 11 cm dimensions, put the glass plate on a piece of aluminum foil and put the foil on a shoe box or plastic storage box. Pour alumina over the glass plate and using a graduated pipette roll out the alumina like pie dough in a thin layer over the glass plate. Drop the sample in spots along an imaginary line about 1 cm above the bottom of the plate using a micropipette. Lean the plate on an evaporating dish in a large specimen dish with the hexane as the solvent in the bottom of the dish. Cover the dish with a large dessicating dish lid. Observe your sample with and without a UV lamp. Place the sample in the dark while using the UV lamp. Look for pink fluorescence along the bottom of the sample and very small dots of blue fluorescence at the top of the lipid curve. These are fluorescent compounds that are also isolated on the chromatograph. Compare your chromatograph with other chromatography tools of classmates.

Chromatography Assessment Name_____Date_____

Answer the following questions after completing the chromatography lab and sharing the results of all three types of chromatography techniques used in this laboratory exercise.

1. Why did Dr. Sapozhnikova use chromatography to separate different compounds?
2. Why was sodium sulfate, Na_2SO_4, added to the tissues and to the top of the column chromatography?
3. What are some other environmental research problems that could be solved using chromatography?
4. Can you name some organizations that employ scientists who use chromatography to insure that you eat fish that are free of toxic levels of chemicals? What levels of polycyclic aromatic hydrocarbons does the EPA allow in our environment?
5. Compare the results of each technique?
6. If you were a scientist, which technique would you use for isolating chemical compounds with different properties and why?

LESSON EIGHT
Limiting Reagents

DEVELOPED BY DENIE RAVENEL

FOCUS

A balanced equation indicates the proportions between reactants and products. More specifically, the coefficients in the equation indicate the mole ratios between the chemical substances. Because of this, it is possible to determine how much product will be produced from a given amount of reactant. This predicted amount can be compared with the actual amount produced to determine the percent yield of the reaction. Stoichiometry provides methods for solving mass-mass and mass-volume problems. Real life processes often involve imperfect yields and non-proportional mixtures of reactants. The limiting reagent controls the amount of product made.

GRADE LEVEL

Grades 9-12

SUBJECT AREA

Chemistry

FOCUS QUESTION(S)

- How does one recognize a balanced equation?
- What is a limiting reagent?
- Why do we add an excess of one reactant to a reaction?
- How do we choose which reactant to add in excess?
- How is the amount of product that should be produced determined?
- What is the difference between theoretical and percent yields for a reaction?

SOUTH CAROLINA CHEMISTRY STANDARDS

Standard C-4: The student will demonstrate an understanding of the types, the causes, and the effects of chemical reactions.

C-4.1 Analyze and balance equations for simple synthesis, decomposition, single replacement, double replacement, and combustion reactions.

C-4.3 Analyze the energy changes (endothermic or exothermic) associated with chemical reactions.

C-4.4 Apply the concept of moles to determine the number of particles of a substance in a chemical reaction, the percent composition of a representative compound, the mass proportions, and the mole-mass relationships.

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C-4.5 Predict the percent yield, the mass of excess, and the limiting reagent in chemical reactions.

Standard C-6: The student will demonstrate an understanding of the nature and properties of various types of chemical solutions.

C-6.11 Use a variety of procedures for separating mixtures (including distillation, crystallization filtration, paper chromatography, and centrifuge).

Standard C-5: The student will demonstrate an understanding of the structure and behavior of the different phases of matter.

C-5.8 Analyze a product for purity by following the appropriate assay procedures.

Standard C-1: The student will demonstrate an understanding of how scientific inquiry and technological design, including mathematical analysis, can be used appropriately to pose questions, seek answers, and develop solutions.

C-1.1 Apply established rules for significant digits, both in reading a scientific instrument and in calculating a derived quantity from measurement.

C-1.2 Use appropriate laboratory apparatuses, technology, and techniques safely and accurately when conducting a scientific investigation.

C-1.3 Use scientific instruments to record measurement data in appropriate metric units that reflect the precision and accuracy of each particular instrument.

C-1.5 Organize and interpret the data from a controlled scientific investigation by using mathematics (including formulas, scientific notation, and dimensional analysis), graphs, models, and/or technology.

C-1.6 Evaluate the results of a scientific investigation in terms of whether they verify or refute the hypothesis and what the possible sources of error are.

C-1.8 Use appropriate safety procedures when conducting investigations.

Ocean Literacy: Essential Principles and Fundamental Concepts

6: The ocean and humans are inextricably interconnected.

e. Humans affect the ocean in a variety of ways. Laws, regulations and resource management affect what is taken out and put into the ocean. Human development and activity leads to pollution (point source, non-point source, and noise pollution) and physical modifications (changes to beaches, shores and river). In addition, humans have removed most of the large vertebrates from the ocean.

APPROXIMATE TIME

1.5 days to allow for drying.

MATERIALS

Per Lab Group:

- 600 ml beakers
- stirring rod
- filter paper
- funnel
- eggshell
- white vinegar, ~ 5%
- distilled water

BACKGROUND INFORMATION

Eggs are one of the most effective, non-invasive ways to measure the health of an animal population. Turtle eggs that did not hatch and Arctic bird eggs from non-threatened species are examples that are used to monitor the global movement of toxins in the environment. Some of these contaminants are legacy contaminants like DDT and toxaphene (used widely in the south on cotton crops) that are no longer in use. Others are emerging contaminants like flame-retardants, Scotchguard, and teflons (one use is in popcorn bags). The monitoring allows scientists to track the movement of the contaminants from application location to non-target organisms eventually affecting the entire food chain. Much of this movement occurs through biological magnification and the predator/prey relationship or sublimation and deposition during various seasons (the Grasshopper Effect) as well as other methods. It is suspected that DDT disrupts the endocrine system which interferes with calcium metabolism producing weak shells that do not protect the developing offspring. Perching and farm birds do not experience the same build up of DDT because they eat low level consumers that have relatively low concentrations of contaminant. In raptors or top predators, the levels of contaminants quickly accumulate due to biomagnification.

The issue of contaminants is especially pressing in estuarine environments with the run-off from agriculture, mining, waste disposal sites, and animal husbandry to mention a few. Heavy metals from discarded computers, animal feeds, pesticides, fertilizers, catalytic converters, and car electronics mix with the halides in salt water and change oxidation state.

Scientists often look at the thickness of the eggshell and run tests on the contents. This lab looks at the concentration of calcium in eggs. It is a double replacement reaction using the egg as the limiting reagent and an excess of vinegar. The actual yield of calcium acetate and the amount of calcium in the egg will be determined.

TEACHER TIPS

Students will:

- Determine the %calcium carbonate in an egg.
- Write and balance an equation
- Perform stoichiometric calculations using a balanced equation and mole ratio and molar mass
- Identify the limiting and excess reactants in a reaction based on calculations.
- Calculate the amount of product based on the limiting reactant.
- Calculate theoretical and percent yields for a reaction.
- Measure the yield experimentally
- Timing – 1.5 days due to the drying. Calcium acetate is used to make sterno in the S'mores lab. Students can save their products to use in that lab.

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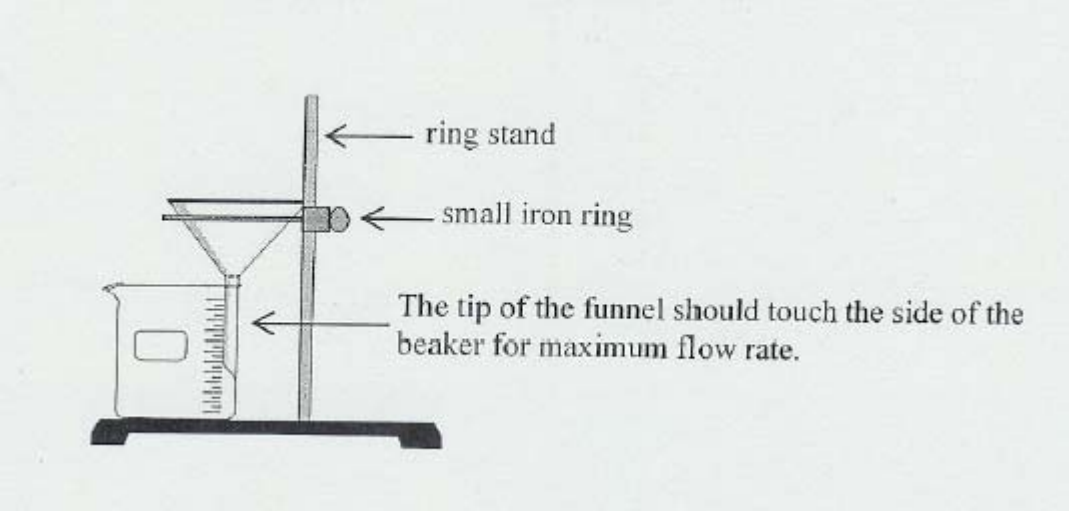
STUDENT PROCEDURE

PROCEDURE:

1. Clean the eggshells and remove the membrane. Allow the shells to dry. Crush between 20 and 30 grams of shell. Determine the mass of the sample.
2. Place the weighed shells in the beaker and add 30 mL of vinegar. Stir. Add an additional 30 ml of vinegar. Add 40 mL more of vinegar. Continue to stir for 10 minutes after the foam stops growing.
3. Weigh an additional 400 or 600 mL beaker that will be used to catch the filtrate. Filter the shell-vinegar solution through the filter paper in the funnel into the pre-weighed beaker. The solution that comes through the funnel (filtrate) should be completely clear. Add 5 to 7 mL distilled water to the beaker to remove the rest of the mixture and pour this through the funnel. Repeat using 5 to 7 mL distilled water until the entire solid is in the funnel, Rinse the beaker with 5 to 7 mL distilled water and filter.



4. Set the beaker containing the filtrate on a hot plate. Gently heat the solution until the salt is dry. (Start at a low setting and then increase as the water evaporates.) Make sure that all the condensation is gone from the sides of the beaker. If the salt appears to be dry but there is still water on the beaker walls, see the instructor. If the salt pops out of the beaker, carefully remove the beaker from the hot plate and see the instructor. When the beaker is cool

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(check the bottom), weigh it to find the mass of calcium acetate produced

5. Determine the % yield of calcium acetate/

Data:

Construct a data table for the reaction to display your laboratory measurements. Make sure that each value is clearly labeled.

Analysis:

Write a balanced equation for the reaction.

Calculate the actual mass of calcium acetate produced (actual or experimental yield).

Using the balanced equation, calculate the mass of carbon acetate that should be produced from the mass of calcium carbonate that you used (theoretical yield). Assume that the clean, dry eggshell is 100% calcium carbonate.

Conclusion:

Calculate the percent yield of the calcium acetate produced in the reaction using the equation below (show your work).

$$\% \text{ yield} = \frac{\text{experimental yield}}{\text{theoretical yield}} \times 100$$

A perfect percent yield would be 100%. Comment on your degree of accuracy and suggest possible sources of measurement error for the calcium acetate. How could these errors be reduced in the future? Why did we not calculate the percent yield of water? Why did we not calculate the percent yield of the carbon dioxide? Does the assumption that we made about the eggshell affect the results? Support your answer.

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STUDENT WORKSHEETS

NAME _____

SECTION # _____

MATERIALS:

- 600 ml beakers
- stirring rod
- filter paper
- funnel
- eggshell
- white vinegar, ~ 5%
- distilled water

NAME _____

SECTION # _____

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Data and Calculations

1. Mass of weighing paper and eggshells _____

2. Mass of weighing paper _____

3. Mass of original shells _____

4. Mass of beaker and dry calcium acetate _____

5. Mass of beaker _____

6. Mass of calcium acetate produced _____

Calculations: Show all work

1. Theoretical yield of calcium acetate _____

2. Percent yield of calcium acetate _____

3. Grams of calcium in the original sample. _____

4. Percent calcium in the eggshell _____

Dow/NSTA Summer Workshop Lesson Plan

Activity: **Parts Per Million**

Grade Level: 9-12

Prepared By: Susan Cooper
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What We'll Study...

The concept of parts per million (ppm) using a Texas Instruments Calculator-Based Laboratory (CBL) and colorimeter or a Spectronic 20 spectrometer.

Did You Know...

When we throw something away, wash it down the drain, or burn it, the elements present in the substance may become rearranged to form new substances, but the elements are still there. It is important for us to know not only what chemicals we are putting into the environment but also how much.

It is now possible for scientists to measure the amount of contaminants present in air or water samples in terms of parts per thousand (ppt), parts per million (ppm), parts per billion (ppb), parts per trillion, or even smaller amounts. These concentrations are very small, but they are important. The smallest amount that can be detected is the detection limit. During the past 50 years, the detection limit has become very small; in some cases, special instruments can detect just a few molecules.

A part per million is equal to:

- one penny in $10,000
- one minute in two years
- one dime in a one-mile-high stack of pennies

A part per billion is equal to:

- one penny in $10,000,000
- one pinch of salt in 10 tons of potato chips
- one second in 32 years

A part per quadrillion is equal to:

- one penny in $10,000,000,000,000
- one second in 320,000 centuries

Many organic substances can biodegrade by bacterial action into water and carbon dioxide. Scientists often refer to these bacteria as "bugs." These bugs need nutrients to live, but excess nutrients containing nitrogen and phosphorous may be discharged to a receiving body of water. These nutrients promote algae and plant growth, which can affect the amount of dissolved oxygen (DO) available for fish as well as the amount of light reaching lower depths in the water. Most fish need at least 4 ppm of dissolved oxygen to survive, and some species such as bass and trout need much more.

One part per million is the same as 1 mg/L for water solutions. This can be shown as follows:

$$1 \text{ mg} = 10^{-3} \text{ g}; \; 1 \text{ L} = 10^{3} \text{ mL}$$

The density of pure water is measured in g/mL, therefore 10^{-3} g/10^{3} mL = 10^{-6}, or 1 ppm. If the drinking water in your city is fluoridated at the water treatment plant, it is probably added at 1 ppm.

Substances such as acids and bases are neutralized to salts before being discharged to a large body of water such as a river. Depending on the risk that a chemical poses to the environment, dilution with water may be a safe way to dispose of it.

More than 50 percent of the people in the United States depend on groundwater for their drinking water. The best method for protecting this valuable resource is to prevent contaminants from ever entering our groundwater.

All waste treatment processes usually produce solids, which are transferred to a landfill or incinerator after treatment.

OBJECTIVES

Students will:

- Explore the meaning of parts per million.
- Learn how to make serial dilutions.
- Learn what common products may be disposed of down the drain.
- Graph their results (optional).

MATERIALS (PER LAB STATION)

Experiment Using CBL

- Colorimeter with 6 cuvettes
- Texas Instruments CBL
- TI-83 calculator
- Vernier CHEMBIO program for TI-83 (available free from Vernier)
- Graph Link software (optional)
- red food coloring
- 6 beakers, 100 mL or larger, or plastic cups
- 10-mL graduated cylinder
- 100-mL graduated cylinder
- stirring rod

Experiment Using Spectronic 20

- Spectronic 20 with 6 cuvettes
- red food coloring
- 6 beakers, 50 or 100 mL, or plastic cups
- 10-mL graduated cylinder
- 6 graduated pipets, or 1-mL volumetric pipets
- stirring rod

SAFETY AND ENVIRONMENTAL CONSIDERATIONS

- All substances may be safely poured down the drain.

PROCEDURE

Part I

Experiment Using CBL

1. Label six beakers or cups with numbers 1 through 6. Measure 90.0 mL of distilled water into each of the beakers.
2. Fill a cuvette to the line with concentrated food coloring. This concentration will be called 1/1, one part per one.
3. Into beaker #1, accurately measure 10.0 mL of concentrated food coloring and stir. This concentration is 1/10, one part per ten.
4. Carefully measure 10.0 mL of beaker #1 and stir into beaker #2. This concentration is 1/100, one part per hundred.
5. Continue until you have stirred 10.0 mL of beaker #5 into beaker #6. The last beaker has a concentration of one part per million.
6. Before continuing with the CBL colorimeter, complete the data table except the percent transmittance column. Be sure to observe the color with a white background behind the beaker.

Experiment Using Spectronic 20

1. Turn on the Spectronic 20 and allow it to warm up while preparing the solutions to be tested. Follow the instructions for the spectrometer. Most require 10 to 15 minutes to stabilize before use. To duplicate the experiment using CBL, set the wavelength to 470 nm if using red food coloring.
2. Label six beakers or cups with numbers 1 through 6. Measure 9.0 mL of distilled water into each of the beakers.
3. Fill a graduated pipet or 1-mL volumetric pipet to the line with concentrated food coloring. This concentration will be called 1/1, one part per one.
4. Into beaker #1, accurately measure 1.0 mL of concentrated food coloring and stir. This concentration is 1/10, one part per ten.
5. Carefully measure 1.0 mL of beaker #1 and stir it into beaker #2. This concentration is 1/100, one

part per hundred.
6. Continue until you have stirred 1.0 mL of beaker #5 into beaker #6. The last beaker has a concentration of one part per million.
7. Before continuing with the spectrometer, complete the data table except the percent transmittance column. Be sure to observe the color of each solution with a white background behind the beaker.

Part II

Experiment Using CBL

1. Connect the colorimeter to the CBL with a CBL-DIN adapter in Channel 1, and link the TI-83 calculator to the CBL with a link cable. Turn on the CBL and the calculator. Press the PRGM key on the calculator and select the CHEMBIO program. Follow the prompts on the calculator to collect data for the experiment.
2. Perform a two-point calibration (0% and 100% transmittance) for the colorimeter and CBL with the TI-83. If using red food coloring, use the blue LED (470 nm).

   a) First, close the lid of the colorimeter, set the colorimeter knob to 0% T, and allow the reading on the CBL to stabilize. Press the [Trigger] button on the CBL and enter 0 when asked to Enter Reference.
   b) Set the knob on the colorimeter to 470 nm (if using red food coloring) and insert a blank cuvette (containing distilled water only). Allow the reading on the CBL to stabilize and press the [Trigger] button on the CBL. Enter 100 at the Enter Reference prompt.

1. Fill each cuvette to the line with successive dilutions of food coloring that were prepared in Part I. To use the calculator to store the data, use the trigger/prompt mode on the calculator program and enter the concentration of each solution when requested. Note: The calculator will store concentration in List 1, absorbance in List 2, and percent transmittance in List 3.
2. To view the graphs, use the Stat Plot key. Plot 1 should have stored List 1 and List 2 so that the graph will show absorbance vs. concentration. To view percent transmittance, turn off Plot 1 and turn on Plot 2, which should have List 1 and List 3. Examine each graph using the graph functions on the calculator.
3. (Optional) Graph your results by downloading the information stored in the TI-83 to a computer using the Graph Link software and Vernier's Graphical Analysis program.

Experiment Using Spectronic 20

1. Perform the proper calibration on the spectrometer using a blank of distilled water. Follow the procedures for setting 0% and 100% transmittance using the guidelines written for your instrument.
2. Fill each cuvette with a different solution, keeping them in order for easy identification. Use good technique and carefully wipe the outside of the cuvette with soft tissues or paper towels before

inserting the cuvette into the sample holder.
3. Measure the percent transmittance for each of the solutions and record the information in your data table.
4. (Optional) Graph your results using a graphing calculator or graph paper, or log the data into a graphing calculator and link to a computer to print data from the computer printer.

DATA AND OBSERVATIONS

Data Table

Beaker #	Conc. Fraction	Conc. Decimal	Conc. Exponent	% Transmittance	Color
1	1/10	0.1	10^{-1}		
2					
3					
4					
5					
6					

QUESTIONS

---

1. At which concentration could you no longer detect the red food coloring with your eyes?
2. Did the colorimeter or spectrometer enable you to detect a difference between each concentration? Explain.
3. Sketch both graphs (absorbance vs. concentration and percent transmittance vs. concentration). Discuss the reason for the differences. Which is more linear?
4. Give an example of a chemical pollutant that is not detectable by our senses but causes harm to people or the environment.

OPTIONAL EXTENSIONS

Disposal of Household Products

May these substances safely be poured down the drain when you are finished using them? If not, how should you dispose of them?

1. Antifreeze (ethylene glycol)
2. Weed killer or insecticides
3. Used motor oil
4. Detergents
5. Vanish drain cleaner
6. Woolite cold water wash
7. Expired medicines
8. Ammonia
9. Soap
10. Latex paint
11. Paint thinner
12. Hydrogen peroxide
13. Nail polish remover
14. Pepto-Bismol
15. Fluoride treatment
16. Rubbing alcohol
17. Vegetable scraps (garbage disposal)
18. Grease (from bacon or cooking)

Note: To properly dispose of any specific substance, call the county agency in charge of waste disposal in your area, check the label and other information provided by the manufacturer, or contact the manufacturer for more information.

Determining Optimum Wavelength (using Spectronic 20)

1. Determine the optimum wavelength to record the percent transmittance data for the food coloring you are using. To do so, use a sample of solution from beaker #4.
2. Set the spectrometer to 340 nm and calibrate the instrument at 0% and 100% transmittance as before. Insert the sample cuvette and record the transmittance.
3. Remove the sample and reset the wavelength at 360 nm. Reset 0% and 100% transmittance, insert the sample cuvette, and record the reading.
4. Continue moving the wavelength up by 20 nm increments to a maximum of 580 nm. Each time, you must reset 0% and 100% transmittance. Record your data after each reading.
5. The optimum wavelength will be the reading that has the least transmittance (greatest

absorbance). This wavelength may vary depending upon the color of food coloring used or the brand of food coloring used.

Evaluation of a Different Food Color (using Spectronic 20)

1. Select a different color (or brand) of food coloring. Determine the proper (optimum) wavelength for recording the data. See "Determining Optimum Wavelength" discussed above.
2. Perform the serial dilution in the lab procedure for the new food coloring. Test to see how the different coloring compares with the original coloring used.
3. Propose hypotheses to explain any differences you may detect. Plan a procedure to test one of your hypotheses and have your instructor verify your procedure before use.

NOTES TO THE TEACHER

Answers to the Disposal Extension

1. No; antifreeze (ethylene glycol) is biodegradable by bacterial action ("bugs"); however, it is very poisonous even in small amounts to pets and people, so it should be disposed of so that there is no danger to them. Read the label for instructions on proper disposal.
2. No; weed killer and insecticides may be toxic to fish and may not be readily biodegradable. They also may kill the "bugs" (bacteria) at the wastewater treatment plant. Read the label for instructions on disposal. The safest disposal method is to take them to a hazardous waste collection center.
3. No; used motor oil may not be disposed of down the drain or poured on the ground. It does not biodegrade, and it contaminates our groundwater. It should be recycled.
4. Maybe; detergents and shampoos may contain phosphates or surfactants that may not be biodegradable. Read the label or other information provided with the product, or contact the manufacturer.
5. Yes; Vanish cleaner is mostly sodium acid sulfate, a salt which may be washed down the drain.
6. Yes; Woolite wash contains no phosphates, and the organic surfactants are biodegradable.
7. Yes; bleach is a 5% solution of sodium hypochlorite, a salt which may be safely washed down the drain.
8. Yes; ammonia decomposes to a salt and nitrogen.
9. Yes; medicines are degradable.
10. No; but latex paint is degradable and may be safely disposed of in a sanitary landfill.
11. No; paint thinner is not biodegradable. If flushed down the drain or poured on the ground, it contaminates the groundwater. It should be taken to a hazardous waste collection center or recycled.

12. Yes; hydrogen peroxide decomposes into oxygen and water.
13. Yes; nail polish remover is degradable.
14. Yes; Pepto-Bismol is degradable.
15. Yes; fluoride treatment is a salt that is not harmful to the environment.
16. Yes; rubbing alcohol is degradable.
17. Yes; vegetable scraps may be safely disposed of in the garbage disposal; however, a more cost-effective method is to compost.
18. Yes; although grease can clog drains and damage septic systems, it will degrade eventually and causes no environmental damage.

Additional Background

1. Try the experiment yourself first. Some food colorings should be used undiluted, while some need to be diluted for the standard (1/1) solution so that there will be a difference between the first two readings. If that is true for the food coloring you are using, make a standard solution for the students to use for steps 3 and 4.
2. This activity can be performed in a group setting by using different lab groups to prepare different portions of the serial dilution to analyze. In this way, maximum use may be made of limited equipment. Even with only one spectrometer or colorimeter, several groups can test and record data rather quickly.
3. In using red food coloring for the experiment using the Spectronic 20, the optimum wavelength was determined to be about 500 nm. This was true for the two different brands of food colorings used. You may need to test the particular brand of food coloring you have available. There was very little difference in percent transmittance recorded from the two different colorings.
4. Often the last two dilutions in the CBL experiment were measured as having the same absorbance and percent transmittance. This was just as good as using our eyes.
5. Standard food colorings may be obtained from supply houses. One source is Warner-Jenkinson (1-800-325-8110). A source for bulk food coloring is Cuisenaire (1-800-237-0338). The use of pure food colorings may provide interesting results. Food colorings from grocery stores are often blends of different colors.
6. The relationship between absorbance and percent transmittance is logarithmic and inverse.
7. If a colorimeter or Spectronic 20 spectrometer is not available, this lesson may be done simply by observing the colors and discussing the limits of using our senses to detect impurities in water.
8. If desired, relate the use of exponents to pH:

- 1 ppt = 10^{-3}. If the [H+] is 10^{-3}, the pH of the solution is 3. Examples are soft drinks, vinegar, grapefruit juice.
- 1 ppm = 10^{-6}. If the [H+] is 10^{-6}, the pH of the solution is 6. Rainwater has a pH of around 6.
- 1 ppb = 10^{-9}. If the [H+] is 10^{-9}, the pH of the solution is 9. This includes many detergents.

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