You Can Make It! Chemical Engineering of Consumer Items

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OVERVIEW

I am a secondary Chemistry and Biology teacher within the Pittsburgh Board of Education. The school at which I teach is 90% Afro-American. Due to the fact that many of these students live in low socio-economic regions of the city, their educational values are quite different than the ones that you or I may be accustomed to. They are most interested in how the subject matter will benefit them "Now". Thus, it is the intent of this curriculum to present *Chemical Engineering of Consumer Items* in a manner that will educate, entertain, and provide students with marketable skills that allow them to see a connection within today's world.

This unit will enlighten students as they journey on a theoretical self-indulging alteration of the body and mind. Students will be instructed to create a consumer substance. In doing so, they will enhance their knowledge and skills in various chemistry content areas. After completion of each lab, students will research healthy aspects and alternative materials necessary to engineer an improved product. The following are a list of labs that will guide students throughout this unit:

Laboratory/Research Activity	**Chemistry Content Link**
Indulge-Making Bath Salts	Mixtures
Silky, Silky-Making Lotion	Temperature Conversions
Calming Candle-Homemade gel candle	Saturated and Unsaturated Compounds
Chap Away-Homemade lip balm	Percent Composition
Clean-Making Soap	Hydrolysis
Myles' Styles-Homemade Hair Perm	pH

RATIONALE

It is common talk among educators to discuss feelings regarding students nowadays wanting to be entertained in the classroom. Students are seemingly uninterested in conventional presentations of subject matter. They do not engage in content material unless they feel it is relevant to them. Unfortunately, when students tune out, not only are they missing out on pertinent education but ultimately on job opportunities and financial success. I believe that one of the biggest challenges that educators face today, in addition to providing students with content knowledge useful for today's job market, is the relevant means by which this content is presented to them.

During the Industrial Revolution Era, education in this country was geared toward preparing workers for factory jobs. The jobs required low level abilities and rote memory. However, they are a thing of the past. Today, students must learn to analyze, evaluate, problem solve, think independently, and work well with others.

Unfortunately, as children get older their passion for learning seems to diminish. A large number of students drop out before graduating. Many more may be present in the classroom yet mentally absent. Thus, it is imperative that we find a vehicle by which we can stimulate them. We must provide our future world leaders with what is necessary to succeed and in a manner by which they can relate to at present.

The lab experiences in this unit will allow students to:

1. Be involved with issues that they regard as vital
2. Be actively engaged in learning.
3. Be involved in real-life experiences.
4. Work in heterogeneous groups.
5. Compare, analyze, synthesize, evaluate, generalize, and problem solve.
6. Review their work and rework it in order to make improvements.

7. Be involved with high-tech information access through electronic learning or computer networking.

The curriculum emphasis is in Chemical Engineering. It encompasses project-based learning, which shifts away from traditional classroom practices such as isolated teacher-centered classes. Learning activities are student-centered and integrated with real world concerns and practices. The curriculum content addresses Standards deemed Necessary by the State in reference to Science and Technology. The intended audience is mainstream Chemistry I. However, adjustments can be made to suite higher/more advanced grade levels.

Research capability will be acquired through Internet based searches. Students will analyze, evaluate, and modify laboratory investigations based on research findings, so as to create "New and Improved" versions of their substances. Laboratory and group investigations shall emphasize higher-order thinking skills. Investigations and research will be collaborative. However, each student will be responsible for submitting a formal laboratory report upon completion of a lab. I want them to research what makes certain items "New and Improved" I want them to inquire what needs change; What modifications are involved?

The following is a detailed overview of the chemistry content associated with each activity:

Laboratory/Research Activity	**Chemistry Content Link Description**
Indulge-Making Bath Salts	Students will determine whether substances mixed are heterogeneous or homogenous.
Silky, Silky-Making Lotion	Students will be required to determine the boiling point of "homemade" lotion. They will convert from degrees Celsius to Kelvin and determine an average boiling point for each.

Calming Candle-Homemade gel candle	Students will observe a demonstration of a physical and chemical change. They will relate materials in the demonstration to those in the lab and determine which substances have undergone a physical or chemical change. Research emphasis will encompass Flash Point levels and other effects of coloring and fragrance.
Chap Away-Homemade lip balm	Students will weigh each ingredient in order to determine its percent composition relative to the balm.
Clean-Making Soap	Students will observe hydrolysis/saponification by combining a fat and metal hydroxide.

INDULGE- MAKING BATH SALTS

A lab of mixtures

Background/Teaching Strategy:

Note: This is a very short and simple lab. It should be presented following an initial introduction of mixtures.

Invite students to smell a variety of fragrant oils. Discuss how various fragrances can serve as therapeutic devices that relieve tension and/or alter moods. Ask the students to take a second whiff of the fragrances in order to describe in one word how it makes them feel. Explain that they will be using one or a combination of these oils as aromatherapy additives in bath salts. In doing so, they must determine whether the combination of substances represent heterogeneous (appears different throughout) or homogeneous (appears the same throughout) mixtures.

Objectives: The purpose of this lab is to observe mixtures (heterogeneous vs. homogenous) while creating a natural aromatic bath salt. Afterwards, students shall research ingredients necessary to make a custom "New and Improved" version.

Science and Technology Standards: 1,2,6,9

Ingredients/Material:

100ml Epson Salt, 100 ml Sea Salt, 1 Finely Ground Alka-Seltzer Tablet, 10 ml fragrant oil, 5-10 drops of food coloring (optional).

Procedure:

Note- Refer to Table after each combination of ingredients have been mixed

1. Mix 100mls of Epson Salt with Sea Salt
2. Stir in ground Seltzer Tablet with salt mixture.
3. Add oil slowly while stirring the salts. (Do not over moisten)
4. Add 5-10 drops of food coloring (optional).

Table:

MIXTURE	HETEROGENOUS	HOMOGENEOUS	REASON
Epson salt and Sea Salt			
Seltzer Tablet and Salt			
Oil with Seltzer/Salt mix			
Coloring with oil/Seltzer/Salt mix (optional)			

Post Lab Teaching Strategy:

Have students soak their hands in their salt bath. They should describe how it makes them feel. Afterwards, they should research various natural fragrances and additives that will improve their salt bath prior to executing this lab again.

Bibliography/Suggested Readings:

Browning, Marie. Natural Soapmaking. Sterling Publishing Co; Inc. New York. 1999-This book offers some great ideas about making various kinds of soaps and salts. It also offers techniques on packaging in order to make the product more appealing.

http://www.biochemica.com/oils.html - This site provides vital information regarding exotic oils from nature. It describes the chemical make up of the oils and a detailed usage guide for each of the oils.

http://www.cranberrylane.com/soapmaking.html - This site provides remarkable information on how to create various scents for soaps and other products. All of the ingredients that the site recommends are natural additives. It also offers a trouble shooting guide is very helpful.

SILKY, SILKY (Making lotion)

Temperature Conversions

Background/Teaching Strategy:

The Celsius Scale readily determines reference temperatures of freezing (O^{o} C) and boiling (100^{o} C) of water. In fact, many people are accustomed to measuring in Celsius Degrees and are knowledgeable about the freezing and boiling points of water. However, The Kelvin Scale is also used in physical science. Its referenced freezing point of water is 273.15 or 273K. The referenced boiling point is 373.15 or 373K. The 0 point on the Kelvin scale is referred to as Absolute 0. At this point, the corresponding temperature on the Celsius Scale is -273^{o}C. Therefore, K= ^{o}C + 273 and ^{o}C = K - 273.

These are basic algebraic equations. Review these with your students prior to doing the lab. I would suggest allowing students to become comfortable with converting Celsius and Kelvin before introducing Fahrenheit, since it involves more manipulation.

Objective:

Students will determine the boiling point of their lotion solutions in degrees Celsius. After successive trials, they will convert the averages to Kelvin temperatures. Afterwards, students will construct a time versus temperature graph using the Celsius averages. Researching common ingredients in lotion will allow students to improve their product

Science and Technology Standards: 2,6,7,8,9

Ingredients/Material:

1.35ml Stearic Acid, 107ml distilled water, 7.29ml Germaben II, 1ml Lemon Fragrance Oil, .5ml Honey Suckle, 1 ml Glycerin, .3 grams citric acid, 16 grams Shea Butter, 4.4 grams Emulsifying Wax, 250ml beaker, 400ml beaker, thermometer.

Procedure:

1. Half fill a 400-ml beaker with water and begin heating over medium flame.

2. Combine all ingredients in a 250ml beaker *Except Germaben II and Fragrance Oils.* Place beaker inside of 400ml-beaker water bath. I

3. Insert thermometer. Be sure that thermometer does not touch any part of the glass, as it will interfere with results.

4. Beginning at time 0, record temperatures approximately every two-minutes.

5. Stop when solution begins to bubble.

6. Repeat the above procedure twice more.

7. Add Germaben II and Fragrance Oils to final product while still hot. Stir occasionally until cool.

Calculations (Numbers in ( ) indicate trials)**:**

Time (1)	Temp. (1)	Time (2)	Temp. (2)	Time (3)	Temp. (3)

Post lab Teaching Strategy:

Have students calculate an average temperature for each time interval (e.g. average all temperatures for time 0). They should construct a graph of Time versus these averaged Temperatures. Afterwards, have the students convert each averaged temperature from degrees Celsius to Kelvin.

Bibliography/Suggested Readings:

http://www.pinemeadows.net/recipes.php#r2 - An excellent resource site for making health/beauty products. The recipes are simple and more importantly, they work!

http://www.snowdriftfarm.com/lotionmaking101.html - If you've been wondering how to translate ingredients on the back of consumer items into simple relevant chemistry compounds, look no more. This site provides the chemical make up and derivation of many ingredients commonly listed on the back of consumer substances. It's a great resource.

Calming Candle (Homemade Gel Candle)-

Physical vs. Chemical Change

Background/Teaching Strategy:

A great way to introduce this lab is to first define what a chemical and a physical change are. A chemical change is one in which the properties of the substance have been altered and or changed into something else. With a physical change, the substance may change form in some way but it remains the same substance.

Half fill a 150 ml beaker with ethanol. Submerge a Dollar bill inside the beaker. . Using tongs to hold the bill above your workbench, ignite the dollar bill with a lighter. Within a few seconds, blow out the firing dollar. Show the students the bill. Ask them whether or not the dollar underwent a physical and or chemical change and why. Ask them about the alcohol. Have the students relate the properties of this demonstration to a burning candle. The dollar bill has not changed. It remains the same. Therefore, the dollar bill has undergone a physical change. Synonymously, the wax in a candle remains the same after lighting. It may melt but it remains wax. However, the alcohol has undergone a chemical change just as the wick within a candle changes chemically and is used up.

Objectives:

The purpose of this lab is to differentiate between physical and chemical properties. In doing so, students will obtain knowledge in order to create a safe and beautiful gel candle.

Science and Technology Standards: 2, 3,6,7

Ingredients/Materials:

(1) 400 ml beaker, thermometer, (1) 250 ml beaker, glass container, Pre-made gel, 6 inch wick w/ base, sand, sea shells, glass rocks, marbles, fragrance and color (optional)

Procedure:

1. Heat pre-made gel in 250ml beaker placed in a 400ml-water bath. Slowly bring to 200-210 degrees F and hold at this temp for 1 hour or until the gel is completely smooth flowing.

   Never allow the temperature to exceed 230 degrees as this may scorch the gel.

2. It is recommended that you do not add fragrance or color to your candles as

   it will lower the flashpoint level of your gel. Lowering the flashpoint level decreases the temperature at which the vapors above your gel can ignite. Thus, fragrance and color can cause candles to be unsafe.

3. Dip wick base in the gel and place in the bottom of the glass container. Hold for a few seconds to allow gel to adhere to the glass. Wait two to five minutes before adding objects to make different effects.

   Note: You can get different effects from different pouring temps: 180-190F

   lots of bubbles 190-200F few large bubbles 200-210F almost no bubbles 210-

   220F Bubble Free. (To insure bubble free candles preheat glass for 10 minutes

   in pre-heated oven at 150F.

Post Lab Teaching Strategy:

Have students compare how the materials in the gel candle are synonymous in physical and chemical properties to the burning dollar. Afterwards, have them research the various designs that people have made using gel candles. More importantly, they should research the cautions one must take when making and using gel candles such as flash point levels and fragrances. Ask them, if they were to recreate their candle, what they would do to improve it.

Bibliography/Suggested Readings:

Ann, Vanessa. Candlemaking For The First Time. Sterling Publishing Co; Inc. 2001. This is a great book that offers ideas on how to create hundreds of designs and embeds for your candles.

http://chemistrystore.com/Candle_Gel.html -This is a very informative site regarding the nature of gel candles. It is more less a question and answer page that provides information regarding the safety of gel candles.

CHAP AWAY (Homemade lip balm)

Percent Composition

Background/Teaching Strategy:

It is sometimes hard for students to grasp the concept of percent composition. They look at the method and decide that there are too many numbers involved and immediately flick the switch in their brains to "off". However, I have found that instead of presenting this concept textually, it helps if it is initially presented using the students as examples. Ask the students to take a count of their peers in the room with red shirts on. Have them write this number down. Then, have them count all of the students with blue shirts and jot it down. They continue the poll of shirt colors until everyone in the room has been accounted for. I then ask them to take a count of total students in the room. Afterwards, I have them divide each number of shirt colors by the total number of peers in order to determine the percentages of that color. My students have shown better success with percent composition when presented this way. Thus, I suggest the following lab as follow up activity.

Note: Lip balm tubes can be purchased at a local craft store

Objective:

Students will calculate and determine the percent composition of the substances in their lip balms. After its completion, students will research alternative ingredients to improve the texture, cohesion, and lastingness of their balm.

Science and Technology Standards: 2,3,6,7,9

Ingredients/Materials:

Beeswax, Coconut oil (Solid at room temperature), Palm Kernel oil, Sweet Almond Oil, Kool-Aid (optional), 250 ml beaker, 400 ml beaker.

Procedure:

The oils should be placed or poured into a 250ml beaker after measuring. *Be sure to record measurements in Data Table.*

1. Weigh 5 grams of Beeswax.

2. Weigh 6.25 grams of Coconut Oil
3. Weigh 3.75 grams of Palm Kernel Oil
4. Weigh 10 grams of Sweet Almond Oil
5. Combine all oils in 150 ml beaker
6. Place the beaker containing the oils in a half-filled 400ml-beaker water bath. Heat until all oils have melted. Stir occasionally.
7. You may add a little Kool-Aid at this time for color (optional)
8. Using a pipette, suction the melted oils into the lip balm containers. Place the containers in a refrigerator for at least an hour.

Calculations:

Use the following table in order to determine the percents of each of the oils in the lab.

OIL	WEIGHT (g)	PERCENT COMP.
Beeswax		
Coconut Oil		
Palm Kernel Oil		
Sweet Almond Oil		
	Total Weight	Total Percentage

Post Lab Teaching Strategy:

After students have determined the percent compositions the oils, have them research its uses. They should also find alternative oils that would produce similar if not better results.

Bibliography/Suggested Readings:

http://www.pinemeadows.net/recipes.php#r2 This site offers loads of free recipe for health and beauty. One of its best attributes is that alternative ingredients are listed.

BE CLEAN-USE SOAP

Hydrolysis/Saponification

Background/Teaching Strategy:

If you haven't noticed the increasing varieties of Body Washes on the market today, where have you been looking? They're everywhere. Everyone wants to feel and smell good. Besides the obvious, soap is one of the major disease fighting mechanisms outside of the body.

Soaps are usually produced by combining a metallic hydroxide (e.g. sodium) with animal fats and/or some other type of oil. The hydroxide is added to the ester of the fat molecule. Water is then removed during hydrolysis. This process is called saponification (See suggested reading sites for further detail).

Have your students write down the brand of soap they use most often. Ask them why they use this brand: Is it because it's cheap? Do they use it because it smells good? Does it make their skin feel soft and smooth? Explain to them the process of soap making/saponification. Tell them that they will be comparing the soap made in the lab today with other detergents.

Objective:

Students will observe hydrolysis during a saponification reaction. In doing so, students will engineer a soap. They will compare this soap to two other detergents. Researching common ingredients will allow for improvements.

Science and Technology Standards: 1,2,6,7,9

Ingredients/Materials:

(3) test tubes, 25ml graduated cylinder, wire gauze, ring stand, gas burner, glass stirring rod, vegetable oil, 20ml water, sodium hydroxide pellets, 20 ml ethanol, Sodium Chloride solution, ring support, (2) 250 ml beakers, (1) 400ml beaker, solution of calcium chloride, solution of magnesium chloride.

Procedure:

1. Pour approximately 10ml of vegetable oil into a 25ml graduated cylinder.
2. Thoroughly mix 20mls of water and 20mls of ethanol in another 250 ml beaker.
3. Slowly while stirring, add sodium hydroxide pellets to the ethanol and water mixture.
4. Set up you heating apparatus. Using a 400ml beaker, fill it half full with water and begin heating.
5. Slowly add approximately 5mls of the hydroxide/ethanol/water solution into the beaker containing the oil. Continue adding 5mls of hydroxide solution every few minutes until is all is transferred.
6. Place the vegetable oil/hydroxide solution into the water bath beaker.
7. Heat and stir for about 30 minutes. The solution should appear homogenous.
8. Add 25mls of cold water to the vegetable/hydroxide solution. *Be sure to use distilled water. Hard water may cause your soap to crumble.*
9. Prepare 100 ml slush of NaCl in a 250 ml beaker
10. Add the hydroxide/oil solution to the slush of NaCl. Stir and allow to completely cool.
11. Using a spatula, skim off the top soap layer and place it in a beaker or other desired container for shaping.

Wait about three weeks before comparing your soap with the commercial brand. The soap is still very basic and not suitable for your skin.

Week 3:

1. Place a pinch (pea sized) of your soap in a test tube labeled A

2. Add 5-10 drops of pre-made calcium chloride solution to a test tube labeled B

3. Add 5-10 drops of pre-made magnesium chloride solution to a test tube labeled C.

4. Shake each test tube. Order the soap reactions from lowest to highest in terms of solubility or amount of bubbles.

5. Using wide range indicator test paper, determine the pH of A, B, and C.

Post Lab Teaching Strategy:

Ask the students to determine which of the soaps they feel is better based on the solubility and pH. Have then research various sites on the Internet to determine what they can do to enhance the fragrance and performance of their soap.

Bibliography/Suggested Readings:

Browning, Marie. Natural Soapmaking. Sterling Publishing Co; Inc. New York.1999. This book offers some great ideas about making various kinds of soaps and salts. It offers techniques on packaging in order to make the product more appealing.

http://www.cranberrylane.com/soapmaking.html This is a great site that suggests various scents and herbs as aromatherapy ingredients. This is a great site for students who are unsure as to what they should add to their soap in order to get desired effects. It also offers various methods of making soap.

Myles' Styles (Making Hair Perms)

pH

Background/Teaching Strategy:

Students are usually very excited about doing this lab. Students are often curious about the effects of acids and bases. Most of them do not realize that they have observed a strong base and weak acid if they got their hair permed. This lab allows students the opportunity not only to observe an acid and base, but also to test the pH of these substances.

Your hair is made up of proteins, which are chains of amino acids. There are 20 different amino acids. Some are positively charged while others are negative or neutral. Cysteine is a common amino acid found in the hair. It forms bonds with other Cysteine molecules giving hair its strength. However, these bonds must be broken in order to change the structure of the hair (e.g. relaxing or curling with a perm).

Sodium hydroxide is a strong based often referred to as lye. It was typical of perms many years ago. Due to its harsh effects, it is not as common today. Instead, researchers use other metallic hydroxides combined with various conditioners in order to deter damage to the hair shaft. After the hair is exposed to sodium hydroxide or other basic solution, it must be neutralized by applying a mild acidic formula. Breaking, smoothing or curling, and reforming the sulfur bonds in the hair causes a permanent wave.

Objective:

Students will observe the effects of a strong base and mild acid. They will determine the pH. Afterwards, they will research alternative metallic hydroxide used in perms.

Science and Technology Standards: 2,4,5,6,8,9

Ingredients:

Human hair sample (weave), curling rod, 50ml NaOH (pH 10-12), 50ml acetic acid, clock timer, hair dryer, (2) 250 ml beaker, pH indicator strips.

Procedure:

1. Pour 50mls NaOH solution in a 250-ml beaker.
2. Measure the pH using indicator strips to determine the strength of the hydroxide.
3. Wrap several strands of straight hair around a curling rod.
4. Submerge the rod in the NaOH solution for approximately 15-20 minutes. The usual time that you would leave a perm on your hair.
5. Rinse the roller with distilled water.
6. Pour 50mls of Acetic acid in a 250ml beaker. Determine the pH of the acid.
7. Combine the a few drops of NaOH solution with a few drops of acetic acid solution in a small test tube. Swirl for approximately 1 minute.
8. Measure the pH of the combined solution.
9. Allow the hair to dry overnight on the rod.

Table:

Substance	pH
NaOH solution	
Acetic acid	
NaOH +Acetic acid	

Day 2

1. Unravel the hair from the rod.

2. Rinse the hair again with water.

3. Blow the hair dry to determine whether or not the wave pattern is permanent.

Post lab teaching strategy:

Have the students research in order to find the type of metallic hydroxide commonly used in commercial perms. Students should also be able to determine other additives that suffice to lessen the abrasive effects of perms.

Bibliography/Suggested Readings:

http://www.cfsan.fda.gov/~dms/fdahdye.html This site is very informative in regards to the hazards of perms. It provides information about how the FDA evaluates products on the market. It also suggests methods of obtaining safer results when perming.

http://www.pantene.com/haircare/hair_twh_77.htm This site offers an excellent tutorial on the many damaging affects on the hair. It is very well illustrated; which allows students to actually see the effects within the hair shaft and cuticle.

http://www.mvhs.fuhsd.org/~i-heng/Biowebsite/journals/vol5/1/a1.html This site outlines a laboratory investigation of varying substances on the hair. While students may not want to read all of the particulars in this lab, it is important for them to know that labs are performed in the real world and not just in your classroom. Also, the results found may be of surprising interest.

Appendix-Content Standards

Science and Technology Standards:
1. All students explain how scientific principles of chemical, physical, and biological phenomena have developed and relate them to real world situations.
2. All students demonstrate knowledge of basic concepts and principles of physical, chemical, biological and earth sciences.
3. All students use and master materials, tools, and processes of major technologies which are applied in economic and civic life.
4. All students explain the relationships among science, technology, and society.
5. All students construct and evaluate scientific and technological systems using models to explain or predict results.
6. All students develop and apply skills of observation, data collection, analysis pattern recognition prediction, and scientific reasoning in designing and conducting experiments and solving technological problems.
7. All students evaluate advantages, disadvantages, and ethical implications associate with the impact of science and technology on current and future life.
8. All students evaluate the impact on current and future life of the development and use of varied energy forms, natural and synthetic materials, and production and processing of food and other agricultural products.
9. All students demonstrate basic computer literacy, including word-processing, software applications, and the ability to access the global infrastructure using current technology.

Activity **Standards Addressed**

Indulge-Making Bath Salts…….1,2,6,9

Silky, Silky-Making Lotion…….2,6,7,8,9

Calming Candle-Homemade Gel Candle……2, 3,6,7,9

Chap Away-Homemade Lip Balm……2,3,6,7,9