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| **Title**  | Analysis of Biodiesel in the Classroom |
| **Introduction**  | The lessons in this module are designed to teach energy production to introductory biology students in the context of biodiesel production. The biodiesel link gives them an application of carbon and nitrogen cycle typically taught during a first-year course. In addition, students will use environmental science, economics and energy analyses to determine whether biodiesel is sustainable and a good idea. This evaluation allows students to make an informed decision after studying the big picture. With petroleum fuel supplies running low, and the interest in greenhouse gases and global warming on the rise, alternative fuels are important for all people. The lessons in this module can each be completed independently of the others, making them appropriate for a physical science, biology, chemistry, or environmental science class.  |
| **Learning Outcomes**  | **Students will*** Learning about energy resources and Biodiesel
* Produce biodiesel in a small-scale laboratory experiment.
* Analyze the quality of the prepared biodiesel.
* Compare and evaluate the usefulness of alternative fuel sources.
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| **Curriculum Alignment**  |

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| HS-PS3-1 | Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. |
| HS-PS3-4. | Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). |
| HS-ETS1-3. | Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts. |

From the NC Essential Standards “unpacked” content for chemistry (<http://www.ncpublicschools.org/docs/acre/standards/support-tools/unpacking/science/chemistry.pdf>)* **2.1.1** Explain the energetic nature of phase changes (contrast heat and temperature, including temperature as a measure of average kinetic energy, and appropriately use the units Joule, Celsius, and Kelvin)
* **2.1.2** Explain heating and cooling curves (complete calculations of: q=mCT, q=mHf, q=mHv using heating/cooling curve data)
* **2.1.4** Infer simple calorimetric calculations based on the concepts of heat lost equals heat gained and specific heat.
* **2.2.1** Explain the energy content of a chemical reaction (interpret potential energy diagrams for endothermic and exothermic reactions including reactants, products, and activated complex-with and without the presence of a catalyst)
* **3.1.1** Explain the factors that affect the rate of a reaction (temperature, concentration, particle size and presence of a catalyst)

<http://www.dpi.state.nc.us/docs/acre/standards/support-tools/unpacking/science/biology.pdf>Bio.2.1 Analyze the interdependence of living organisms within their environments. Bio.2.1.1 Analyze the flow of energy and cycling of matter (such as water, carbon, nitrogen and oxygen) through ecosystems relating the significance of each to maintaining the health and sustainability of an ecosystem. Bio.2.1.2 Analyze the survival and reproductive success of organisms in terms of behavioral, structural, and reproductive adaptations. Bio 2.1.3 Explain various ways organisms interact with each other (including predation, competition, parasitism, mutualism) and with their environments resulting in stability within ecosystems. Bio.2.1.4 Explain why ecosystems can be relatively stable over hundreds or thousands of years, even though populations may fluctuate (emphasizing availability of food, availability of shelter, number of predators and disease). |
| **Critical Vocabulary**  | * Transesterification – a chemical reaction between an alcohol and a triglyceride to produce biodiesel and glycerin
* Triglyceride – oils or fats found in plants and animals; composed of a glycerol (3 carbon chain) backbone with three fatty acid chains (long straight chains of carbon atoms) attached
* Methyl ester – a compound formed from the reaction between an acid and an alcohol
* Biodiesel – a diesel fuel produced from organic sources, such as cooking oil, animal fat, or plant seeds (canola, sunflower, soybean)
* Catalyst – a substance used to speed up the rate of a chemical reaction without being used up during the process; similar to an enzyme in a biological system

The US Department of Energy maintains a full text glossary of terms related to the Biomass Program. The link is: <http://www1.eere.energy.gov/bioenergy/glossary_full_text.html> |
| **Classroom Time Required**  | **Activity 1** - one 90 minute block. Debate**Activity 2** - one 90 minute block. Production**Activity 3** – Two hours with overnight separation of reaction. To make the biodiesel, allow one 45 minute period to warm the oil and add the alcohol and catalyst. The reaction then needs to proceed for at least one hour, followed by separation in a funnel (overnight is ideal).**Activity 4** – 30-45 minutes**Activity 5** – one 90 minute block (Comparision) |
| **Materials Needed**  | **Activity 1 Materials:**Lab Materials (per lab group):* 300 mL soybean oil or canola oil
* 6 g potassium hydroxide
* 60 mL methanol
* Thermometer
* Hot plate/stirrer
* 500 mL beaker
* 250 mL Erlenmeyer flask with stopper
* Glass storage bottle with lid
* Stir bar
* Separatory funnel (optional)

**Activity 4 Materials:**Teacher: Quality Tests for Biodiesel answer keyStudents: Quality Tests for Biodiesel handout, Goggles, gloves and apron for labLab Materials (per lab group):* 15 mL sample of prepared biodiesel
* 10 mL methanol
* 10 mL deionized water
* Stirring rod
* Graduated cylinder
* Thermometer
* pH paper
* 3 test tubes with stoppers
* Balance

**Activity 5 Materials:**Teachers: Comparing Fuel Sources handout answer keyStudents: Comparing Fuel Sources handout, calculator, molecular modeling kit |
| **Pre-activities**  | **Activity 1 – Introduction to Energy, Heat and Temperature as it relates to the biological cycle**.**Activity 2 – Why the need for biodiesel great debate**  <https://docs.google.com/a/abss.k12.nc.us/presentation/d/1l5sCkF8C8dJsiQWUi6pfMyFSmZ09bPDomFvHVOxmD9g/edit?usp=sharing>**Activity 3 – Biodiesel Basics and Production****Activity 4 – Biodiesel Testing****Activity 5 – Fossil Fuel and Biofuel Comparison** |
| **Activities**  | **working** |
| **Assessment**  | Teachers can use a variety of formative assessments that are not graded, but will inform instruction after each activity. The following are some suggestions for these informal assessments.Informational Powerpoint: <https://drive.google.com/file/d/0B9Gu7YBpoFgKTHVhY2ZxOS13c1U/view?usp=sharing>* Entrance/exit tickets – each student fills out a small ticket. The teacher can ask a content question, such as “Name two things you have learned about energy” or an open-ended question, such as “Write one question that you still have about energy cycles .” The teacher can then use the responses to guide future instruction.
* Starter question – The teacher can make a quick power point slide with the carbon cycle and nitrogen cycle within energy production.
* The teacher will show a “YouTube” Video on biodiesel production.
* Thumbs up/thumbs down – A quick poll of understanding by a show of “thumbs up” or “thumbs down” can let the teacher know if students are confused. If students are not likely to give responses in this way, polleverywhere.com or gosoapbox.com are websites that have similar functions.
* White boarding – students may work in small groups. The teacher assigns one problem from the homework sheet and the group puts the solution on the board and explains it to the rest of the class. This provides an easy way to uncover misconceptions.
* Electronic feedback tor review many misconceptions –Kahoot and socrative.

Summative assessments are more formal and are graded. A number of suggested assessments are listed below. Teachers may select work that is appropriate for their classes.* Quiz – a short quiz can be given after Activity 3.
* Class summary – the entire class can create a KWL-type chart once the activity is complete. Padlet.com is one option to do this electronically. A low-tech option is to create whiteboards. Students can use this as a study guide before the test.
* Written test – a test with multiple choice, heat problems, graphs and short answer questions has been included. This test is best given once the entire unit has been completed.
* Lab report – students can write up formal lab reports for Activities 3 and 4.
* Student presentations – students can create a presentation to support or oppose biodiesel production in the United States. Options for formats include: power point; prezi.com; piktochart.com. Students can also make videos, posters or skits. This will be most effective after Activity 5.
* Class debate – students can be assigned roles (environmentalist, farmer, scientist, congressman, etc.) to help them focus research for the debate. The debate will be most productive if it is held after the completion of the unit.
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| **Community Engagement**  | In North Carolina, there are several sites involved in biofuel production or research. These operations offer education outreach by offering tours or guest speakers to school groups. Teachers should brainstorm.* Piedmont Biofuels – Pittsboro, NC – free public tours on Sunday afternoons and the first Friday of each month
* Patriot Biofuels – Greensboro, NC
* Biofuels Center of North Carolina – Oxford, NC – tours are available or guest speakers can visit schools
* Catawba County landfill site – Newton, NC – free tours can be scheduled
* Guest speakers – North Carolina A&T bioenergy center, Greensboro; North Carolina Biotechnology Center, Research Triangle Park.
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| **Websites**  | **Introductory Articles** – these have basic information that you will want to read before you start looking at other aspectsA list of common FAQs* http://biodiesel.org/what-is-biodiesel/biodiesel-faq's
* http://www.patriotbiodiesel.com/category\_s/1820.htm

A great introduction to biodiesel* <http://biodiesel.org/what-is-biodiesel/biodiesel-basics>

Create your own comparison chart for various fuels* http://www.afdc.energy.gov/fuels/fuel\_properties.php

A short article on renewable v. nonrenewable sources of energy* http://www.ecology.com/2011/09/06/fossil-fuels-vs-renewable-energy-resources/

Crunching the Numbers on Alternative Fuels – Popular Mechanics articles* http://www.popularmechanics.com/cars/alternative-fuel/news/2690341
* http://www.popularmechanics.com/cars/how-to/4314657?click=main\_sr

Ending the Food vs. Fuel Debate* http://www.renewableenergyworld.com/rea/news/article/2012/10/ending-the-food-v-fueldebate-researchers-define-surplus-land

Food vs. Fuel Debate – CNBC article* <http://www.cnbc.com/id/48477352>

CDC report on human exposure to fuel oil* <http://www.atsdr.cdc.gov/toxprofiles/tp75-c1.pdf>

**Video Resources –** Each video clip has the time listed at the end of the title “Fast Track” commercial – a biodiesel truck breaks a land speed record (0:37)* http://bcove.me/9cdwh71s

Jay Leno’s Garage – Jay talks to a scientist about using biodiesel in some of his cars (1:31)* http://bcove.me/316xk1ki

Motorweek segment – interviews farmers and various industries using biodiesel (7:55)* http://bcove.me/3yzusjn6

Biofuel lesson from National Defense Education Program – brief description of how organic materials are being developed into gasoline, biodiesel, and jet fuel* http://www.ndep.us/Biofuel

CNN Story on the Catawba County landfill site* http://www.cnn.com/video/?/video/tech/2009/08/20/wolf.green.town.cnn

**Careers in Biofuels**A US Bureau of Labor Statistics report on biofuel associated careers with salaries and credentials* <http://www.bls.gov/green/biofuels/biofuels.pdf>

Biofuel and Biodiesel product development careers – lists job outlook, salaries, personality traits and has links to other related careers* <http://myfootpath.com/careers/science-careers/biofuel-and-biodiesel-product-developer-careers/>

Green Career Guide – basic information about school and expectations for various biofuel jobs* <http://www.greencareersguide.com/Cellulosic-Biofuels.html>
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| **Author Info**  | Syeda Smith is a Biology and Chemistry Teacher at Hugh M. Cummings High School in Burlington NC. This lesson is part of a Kenan Fellowship “Pump New Life into the Classroom with Biofuels” completed at North Carolina A&T University. |

**Discussion Questions:**

1. Describe the principles and process of transesterification.
2. Create a flow chart showing the process of producing biofuels from vegetable oil. (Keyword: Vegetable Oil, Methanol, KOH, Methoxide, Transesterification, Glycerin, and Biofuels)
3. Write the chemical reaction for the transesterification process.

Process:

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1. In a commercial production of biodiesel, 2300 kgs of vegetable oils produces 1100 kg of crude biodiesel. What is the yield of the commercial vegetable?
	1. How does your yield compare to the commercial yield?
	2. What factors could have an impact on your yield?
2. You have now made biodiesel. Can this biodiesel go directly into a diesel engine?
	1. Why or Why not?
	2. If any, what changes would need to be made before placing it into an engine?

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| **Glossary of Terms “Creating Biofuels”** |
| **Biodiesel** | Vegetable or animal fat diesel fuel containing long chain alky (methyl-ethyl, or propyl) esters; made from chemical reacting lipids with an alcohol producing fatty acid esters(Glycerol) |  |
| **Canola or Soybean Oil** | Oil from a rapeseed plant (bio-living product); grows fast; in mustard seed family; low in saturated fat contains omega 3 and omega 6 |  |
| **Glycerol****Glycerin** | Simple sugar alcohol compound; colorless and odorless. It is commonly used to make soap, vitamins, antifreeze, frosting, e-cigarettes, and sweeteners |
| **Heating and Temperature Gages** | Temperature probes (top) and hotplates (bottom) Set temperature 115$℉$ (46$℃$)http://study.com/cimages/multimages/16/linear_degree_conversion.JPG |  |
| **KOH** | Colorless solid (salt) that is strong base; hygroscopic (has the ability to hold water molecules); exothermic (gives off heat); can be interchanged with NaOH; can make soap |  |
| **Methanol** | the simplest alcohol, and is a light, [volatile](https://en.wikipedia.org/wiki/Volatility_%28chemistry%29), colorless, [flammable](https://en.wikipedia.org/wiki/Flammable) liquid with a distinctive odor very similar to that of [ethanol](https://en.wikipedia.org/wiki/Ethanol) (drinking alcohol); highly TOXIC cannot be consumed; produced by anaerobic (without oxygen) metabolism of many varieties of bacteria; small amounts in the atmosphere which burns in oxygen forming carbon dioxide and water | Skeletal formula of methanol with some explicit hydrogens added |
| **Separatory Funnel** | In a separatory funnel, there are two phases, the aqueous layer is polar, and the organic layer is non-polar. Because these two layers share a surface, any polar substances that were initially in the solution will be pulled into the polar/aqueous layer, and any non-polar substances will be pulled into the non-polar/organic layer. The denser of the two layers is then removed via the stopcock |  |
| **Transesterification** | chemical reaction used for the conversion of vegetable oil to biodiesel. In this process vegetable oil is chemically reacted with an alcohol (methanol);triglycerides are converted in alky esters (biodiesel); alcohol replaces the glycerin |

**Creating Biofuels: Transesterification of Soybean and Canola Oil to produce Biodiesel**

*Biodiesel is the first advanced biofuel. It is a renewable clean-burning diesel replacement that reduces the environmental impact by using animal fats, agricultural oils, and cooking oil. This lab will explore the use of making biofuels through the process of transesterification, replacement of one type of alcohol with an ester by combining an alcohol with an acid.*

1. To describe the principles of transesterification
2. To develop a flow chart for producing biodiesel from vegetable oil
3. To write the complete chemical reaction for this process.
4. To list the principles for designing a biodiesel production facility. (List all principles need to design the production and other outliers that will interfere with the production)
5. To determine the reaction rates and its economics influences.

**Materials**

100 mL of Soybean Oil (SO) or Canola Oil (CO)

2g Potassium Hydroxide (KOH)

20 mL methanol

Thermometer

Hot plate/stirrer

250-500mL beaker

250 mL Erlenmeyer flask with stopper

Storage bottle with lid

Stir bar

Separatory funnel

**Experiment Procedures:**

1. Heat a 100 ml of Soybean Oil (SO) or Canola Oil (CO) to 115$℉$ (46$℃$) and pour it into a clean (250mL-500mL)beaker
2. Heat the beaker with oil and stabilize the temperature of the oil. *(Make sure your oil stays between 45*$℃-50℃ $*or the reaction will not occur)*
3. Measure 20 mL of methanol (CH3OH) into a storage bottle or flask
4. Measure .7 grams of Potassium Hydroxide (KOH)
5. Add the KOH to the methanol (Percent concentration of 2%-2g/100mL)
6. Shake the KOH and methanol until the KOH **completely** dissolves. (You have just created methoxide)
7. **Slowly** add the methoxide (CH3OH +KOH) solution with the oil for 2 hours with a laboratory stirrer.
8. Pour off the mixture into a separatory funnel to allow the layer of biodiesel and glycerin to separate. Let it settle.
9. Allow the glycerin to slowly drip from the funnel into the graduated cylinder (**top layer** is biodiesel and **bottom layer** glycerin)
10. Record the volume of glycerin.
11. Add 0.3mL of acetic acid to the top of the funnel and observe the precipitate.
12. Allow the mixture to settle and drain any residual glycerin.
13. **Optional: spray the water to remove the excess glycerin and triglycerides from the separatory funnel for 30 minutes to precipitate out the salt.**
14. Measure the volume of Biodiesel and Glycerin
15. Calculate the Percent Reaction.

**% Reaction=** $\frac{actual amount of biodiesel}{expected amount of biodiesel}$ X 100=\_\_\_\_\_\_\_

The PowerPoint is listed: <https://drive.google.com/file/d/0B9Gu7YBpoFgKTHVhY2ZxOS13c1U/view?usp=sharing>

**Creating Biofuels NoTES**

*Review*

**Limiting \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** that causes a population to reach its **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**.

How these **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**can be density dependent (diseases) or density independent (abiotic-weather related)

Human population on the **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**can cause resources to **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

How we have too many**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_gases** that a destroying our ozone and will evidently change our way of life.

One method is recycling our **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_sources.**

**RENEWABLE VS NON-RENEWABLE**

**Using \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_E energy instead of NON-RENEWABLE energy**

Energy : **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**energy is energy in MOTION and**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**energy is STORED energy. The SUN is both kinetic and potential. The sun store energy and releases it as **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Renewable and Non-renewableEnergy**

Non-renewable energy :resources are in **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**since it take so long for them to replenish. “Once you use them, they can not replenish within our life time”

Renewable energy resources: used often and/**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**to replenish the resources

Examples Renewable or Non-Renewable”:

 **How is Energy Consumed?**

**Where is the ENERGY going?**

**What are the Energy Cost?**

**Where does renewable energy come from?**

Biomass energy: dead and decomposed organism=**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**and Nitrogen Cycle

Water, **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_\_**, and geothermal

What is Biomass?

**Biodiesel Production**

What is biodiesel? **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**is a **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**diesel replacement petroleum (non-renewable), and improving the environment.

Made from a diverse mix of feedstocks including **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**, soybean oil, **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** (lipids) and animal fats.

**A biologist use for Biodiesel**

Biodiesel **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** is used in **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**, chemistry, marketing, and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Biologist study the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_(corn, soybean, and algae) that produce the most amount of lipids and biofuel.

Biologist will test the various producers in different climates using different \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_(nitrogen cycle) for growth.

They also may **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** the producers to yield greater biofuel.

 What are the Components of Biodiesel?

Reactants /Products

Biodiesel production: What is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_-?

Biodiesel production is the process of producing the **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**, biodiesel, through the chemical reactions **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** and esterification. This involves vegetable or **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_oils** being reacted with short-chain alcohols (typically methanol or ethanol).

**National Comparison of Biodiesel**

 **One Benefits of Biodiesel**

**Making Biodiesel**

1. Combine the KOH and methanol

2. Add the oil

3. Shake or Stir.

4. Wait for the oil to separate.

5. Remove the glycerin

**Common Vocabulary Words-Definitions**

Canola Oil, Algae, Soybean Oil Separatory Funnel, KOH-Potassium Hydroxide, Methanol, Hot Plates, Glycerine

 And Canola Oil

Oil from a rapeseed plant (bio-living product); or producers

Can also use **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

* grows fast; in mustard seed family;
* low in saturated fat contains omega 3 and omega 6

Glycerin-common sugar LIPID

* Simple sugar alcohol compound; colorless and odorless.
* Glycerin lipid is commonly used to **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**, and sweeteners
* By product of **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

Temperature

Potassium Hydroxide

**Colorless solid (salt)** that is strong base (pH higher than 6); hygroscopic (has the ability to hold water molecules);

**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** (gives off heat); can be interchanged with NaOH; can make soap.

**Methanol**

the simplest alcohol, and is a light, **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**, colorless, **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** liquid with a distinctive odor very similar to that o**\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** (drinking alcohol);

Highly TOXIC cannot be consumed; produced by **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** (without oxygen) metabolism of many varieties of bacteria;

 small amounts in the atmosphere which burns in **oxygen \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_and water**

**Separatory Funnel**

In a separatory funnel, there are two phases, the \_\_\_\_\_\_\_\_\_\_\_\_ (liquid) layer is polar, and the organic layer is non-polar.

The denser of the two layers is then removed via the stopcock.