Date: ____________________ Teacher Name: _________________________

One-day Lesson Plan Outline

Lesson Title: __ Intro to Gas Chromatography _____

Grade level = _Middle or High_X_ Amount of time for this lesson = ____50/90____ minutes (1 week)
(Note: this lesson plans for 3 50 min classes and one 90 min class (Mon, Tues 50, Wed/Thurs 90, and Fri 50. This lesson can be adapted for 5 50 min days easily by splitting Day 3 into two days)

The standards in this lesson are chemistry standards, focusing on how to use the gas chromatograph to identify the chemical in a sample. For a more biology-based lesson, objective three and the standards met can be changed accordingly.

1. Standards and Safety and Materials:

A. Standards – NGSS Standards listed.	HS-PS1-3: Plan and conduct and investigation to gather evidence to compare the structure of substances at the macroscopic scale to infer the strength of electrical forces between particle *(Emphasis on understanding strengths between particles. This comes into play in the gas chromatography since elution order depends on boiling point, and the elution times also depend on interactions with the stationary phase.)* HS-PS1-1: Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. (*Emphasis is on understanding the types of bonds involved in the structure of the chemicals of the standards.)*
B. Safety Concerns	This lab utilizes glassware and the Gas Chromatograph instrument, including injection syringe. Students should be informed on safe handling of glassware and instrumentation. They should wear goggles, aprons, and gloves at all times. The Chemicals used in this lab is at the discretion of the teacher. The standards run through the gas chromatograph may be household chemicals or more common laboratory chemicals; be aware and follow through on the safety information listed on each chemical used. Be careful mixing chemicals for the unknown, refer to the SDS before mixing any chemicals together, as it can be **highly** dangerous to do so.
C. Materials	• Vernier Mini GC Plus Gas Chromatograph • Several Chemical standards appropriate to the students' safety. (Examples: rubbing alcohol, vinegar, food coloring etc) • One chemical unknown (prepared by you, can be a mixture of one or more of the standards if the nature of the chemicals allows) • Logger Pro software • Computers • Assortment of appropriate glassware

2. Objectives

A. SWBAT…	SWBAT **Identify** the types of bonds, size, and polarity of each chemical used in this lab.
B. SWBAT…	SWBAT **Identify** microbes present in a specific region of the world by using the Data Corral website.
C. SWBAT…	SWBAT **Know how to use** the GC (with appropriate injection equipment) and know how to extract data from the graphs given through the software.
D. SWBAT	SWBAT **Draw** a schematic of the GC including the parts of the chromatograph such as the injection septum, the oven, the column, and the detector.
E. SWBAT	SWBAT **Identify** the function of the GC.
F. SWBAT	SWBAT **Apply** the merging of knowledge of GC with knowledge of the chemicals produced by specific microbes to write a theoretical lab procedure to determine the identity of an unknown bacteria specimen.
G. SWBAT	SWBAT **Determine** the identity of an unknown chemical given its chromatogram and those of several standards.

3. Connections, Misconceptions, and Crosscutting Concepts:

A. Real world connections	Gas Chromatography is a widely used piece of instrumentation in the world of chemical research. If one goes into the field of chemistry research, chances are he or she will be

	using a gas chromatograph. The wide range of uses and the incredible power of this instrument will be explored in this lesson, introducing students to the world of scientific research using modern instrumentation. The concepts associated with how the gas chromatograph works can show students that knowing these concepts can lead to the invention of great tools such as the GC. The students will be able to explore for themselves the ways that GC can be used in chemical analysis.
B. Student connections	Microbes are a form of life that humans cannot usually see with the naked eye, but that we interact with very often. The students are familiar with microbes that spoil food, microbes labeled "germs" and other families of primitive life. But students may not know that these microbes can often produce chemicals by which they can be analyzed. This lesson is the amazing bridge between students' knowledge of microbial life and students' knowledge of chemical compounds.
C. Misconceptions	Some students may have a few misconceptions about chemical analysis. It's a tempting thought to think that one could simply run a sample through an instrument and come out with a list of the chemicals and percents. This lab will show the students that the brain behind the instrument is still the scientist who operates it.
D. Crosscutting Concepts	Planning and Carrying out Investigations: Students will complete this cross-cutting concept backwards: by carrying out an investigation learning how compounds can be identified in GC analysis, they will be able to plan an investigation to identify microbial life by the chemicals they produce. Structure and Function: The students will see how the structure of the chemicals differ, and how this can have physical consequences as the chemical makes its way through the gas chromatograph.
E. Academic Language	The students will use academic language such as the following: • Gas Chromatography • chromatograph • Injection oven • Detector • Column • Stationary phase • Mobile phase • Elute • Peak • Data Discovery Tool/Data Corral

4. Hook/*Engagement*

Hook: Day 1	A small beaker will be placed on the table in front of the room with an unknown substance in it. Some sort of label should be on it that says something like "What's in this?"
Hook: Day 2	A beaker full of wet dirt will be sitting out on top of the table. You can even put a label that says "Smell me" so that the students can start thinking about what that smell might be. (Later in the lesson, you can talk about the fact that the scent they smell is geosmin, the chemical produced by the Streptomyces bacteria in soil).
Hook: Day 3	The Gas Chromatograph will be sitting under supervision on the front table.
Hook: Day 4	The Data Corral home page will be loaded and displayed on the screen in the front of the room.

5. Pre-test

Day 1	Pre-test: Verbal Question "How do we figure out what's in a random sample?" Post-test: Explain the main function of the GC and draw a schematic of it. Students will just write and draw these on a blank sheet of paper. Use the schematic from the powerpoint for comparison. Function of GC should also come straight from the powerpoint.
Day 2	Pre-test: Verbal Question "So, the last two days we figured out that the differences in chemical structure can be useful when trying to distinguish different chemicals. But let's take that step further; how do you think we can distinguish different types of tiny life forms. Take bacteria. Given a specimen of bacteria, how could we distinguish it from any other specimen of bacteria? Post-test: Sticky notes from each group explaining how knowledge of the microbes could help identify them if they all look the same.

Date: ____________________ Teacher Name: __________________________

Day 3	Pre-test: Small worksheet outlining the steps of using the GC (Not included: making this yourself while you are practicing the lab beforehand can make the difference between a guide that will be useful to the students and one that will be either overly confusing or oversimplified). Post-test: Students will actually be using the Gas Chromatograph and the teacher should assess informally their understanding of the instrument and how to use them.
Day 4	Pre-test: Pair and Share on this question: "Given an unknown specimen of bacteria, what instrument/method could you use to decide what bacteria it is? (Emphasis will be on two things: Using the GC to determine the chemical composition of some chemical produced by the bacteria and Using Data Corral to determine which types of bacteria it might be (which are in the area that you found the bacteria)

6. Activity/*Exploration*

A. Day 1	<u>Lecture on Gas Chromatography</u>: After hook and pre-test, a mini-lecture on Gas Chromatography will be given to the students. A sample power-point is included. Emphasis of the lecture will be on the following: importance and use of the GC, parts of the the GC, how the GC works, how analysis of chromatograms works. On the sample powerpoint, slide 8 is to be done as a group with the students. Point out the following items: retention time, when compared with known standards, identifies the identity of the compound present. Response shows how much of that compound was present. In our example, dodecane is present, but in much smaller quantities than in the standard sample. Slide 9 is coordinated with the worksheet. Students will be able to follow along on the worksheet, and then complete the second problem on the worksheet by themselves. Post-test will be given.
B. Day 2	*(Note: The data corral had not uploaded any microbe datasets at the time of the writing of this lesson plan. Teachers will have to look at the site and pick out several microbes for analysis. These microbes will have to be 1. Found in data corral by site 2. Differentiable by a chemical that they produce.)* <u>Activity</u>: After the hook and pre-test, the students will break into groups of three or four for the "Meet the Microbe" activity. (Sample is included, but you may create them either for random microbes which produce known chemicals, or look on Data Corral and have the students meet the same microbes they will be looking at on day 4). The teacher will break the students up into groups, one group for each microbe, and give them a corresponding info card. Students must prepare a speech for why this microbe should be elected to the Microbial Senate, including all of the information on the card. You may even hold an informal election afterwards to see which speech had the biggest influence! <u>Discussion</u>: The teacher will break the students up into different groups and they will have a discussion about what was learned from the microbe activity and how it could answer the answer to the Pre-test. The groups will write their answers on a slip of paper with all group members' names on it. After each group is done discussing, there can be a full-group discussion and each of the groups can share with the full class what they wrote down. Conclusion: Teacher wraps up the lesson and collects the Post-test sheets from the groups.
C. Day 3	<u>Run the Samples</u>: after hook and pre-test, students will go into the lab and learn how to use the GC. As the teacher, familiarize yourself with every aspect of the Vernier mini GC Plus so that you can operate it consistently yourself and know all of the pitfalls the students might run into on the lab days. 1. Safety: explain to the students all of the safety information, including what equipment they will need. Look at the SDSs of all the chemical standards you will be using and follow the safety precautions. Make sure all of the necessary personal protective equipment is being employed by each student. 2. Using the worksheet from the pre-test, go through the steps of using the Vernier GC and run the first sample. (A time saving procedure will

	have each group measure one sample and the unknown and let them share data with each other). Then, make sure that they know how to get the chromatograph through the software and save it so they can access it later. Practice this yourself beforehand so you know all the pitfalls. Groups will have to rotate using the GC, so the students can work on their lab reports during the time they are not measuring. Make sure they will have access to computers during this time (bring in laptops if possible) After students use the GC, they can practice getting the graph onto the computer and into a program like excel. (**Note:** It is great to have a teacher-completed and more detailed version of the procedure to use the GC laminated and sitting next to the GC in the lab. This way, the students can see for sure what they are supposed to do next when using the instrument. The best thing to do is put this procedure together yourself as you are performing and practicing the lab in advance). 3. Students will be required to turn in a lab report of today's lab. They will have to turn these in **individually** even though the lab was done as a group. Included is a sample rubric for this lab report, but please use your current system for lab reports. 4. Clean up. Make sure you follow the proper waste disposal procedures that your school has in place appropriate for the chemicals you used in this lab.
D. Day 4	Following the Hook and Pre-test, the teacher will hand out the assignment sheet for the day's activity. Activity: Students will, in groups, come up with a lab procedure plan for identifying an unknown bacteria using the Data Corral and the GC instrumentation. Each group must have access to a computer so they can access the Data Corral Website and type up their formal procedure. The criteria are included on the students assignment sheet (included) and the rubric for this assignment (included). The students will have the whole class period to work and print out their plan.
E. Supplies Provided with lesson	1. GC powerpoint 2. Student worksheet on GC analysis 3. Sample Lab Report Rubric 4. Meet the Microbes sample activity card 5. Microbe ID Assignment sheet 6. Microbe ID Rubric

7. Review/Essential Questions/*Explanation*

A. Low Level Questions – (Knowledge/Remembering and/or Comprehension/Understanding)	Identify the types of bonds in the chemicals used. Identify microbes present in a specific region of the world by using the Data Corral website.
B. Middle Level Questions – (Application/Applying and/or Analysis/Analyzing)	Determine the contents of an unknown given its chromatogram and the chromatograms of several standards.
C. High Level Questions – (Synthesis/Evaluating and/or Evaluation/Creating)	Draw a schematic drawing of the GC system. Make a chromatogram using the GC instrument and appropriate injection equipment. Write a lab report conveying procedure, objective, data, and conclusions. Create a lab procedure which will satisfy a given objective assuming data corral website and GC technology would be available.

8. Assessments (Post-test)/*Evaluation*

A. Formative: (Check for learning in class?) e.g. Oral questions?	The pre-tests will be formative; both verbal questions and worksheets. They are easily checked and responded to during the class period. The lab work will be a formative assessment of whether or not the students are performing the lab correctly. The teacher should constantly be scanning the lab and supervising the groups using the GC not only to make sure they are being

	safe, but also to see that they are understanding how to use the GC and why they are using the GC. Feel free to prompt the students with questions when they seem confused or stuck on part of the procedure.
B. Post-test: ("Same as pre-test"; Compare w/pre-test to inform teaching!)	Post-tests are given for days 1-4 which mirror the pre-tests from that day.
C. Summative: (Check for final learning/understanding) – e.g. Students turn in **constructed** project and **take** 20 question multiple choice test.	The summative assessments will be the lab report, and the Microbe ID Procedure Plan. ***Optional:*** It is sometimes helpful to have a lab viva (oral lab chat) with each of your students and ask them to put into words what they did in lab and how they met the objective of the lab. These can be as short as just a few minutes, but it gives you a good idea of that students' understanding of the lab, perhaps more so than a lab report.

9. Timeline for this lesson:

	<u>Day 1: 50 min</u> Hook: 5 min Pre-test: 5 min Lecture: 15 min Example from Powerpoint: 5 min 2nd example from Powerpoint: 10 min Post-test: 10 min <u>Day 2: 50 min</u> Hook: 2 min Pre-test: 5 min Meet the Microbes: 33 min (15 for group planning, 15 for presenting, 3 for election) Discussion/Post-test: 10 min <u>Day 3: 90 min</u> Hook: 0 min Pre-test: 10 min Safety: 10 min Labwork/Analysis: 60 min Clean-up: 10 min <u>Day 4: 50 min</u> Hook: 0 min Pre-test: 5 min Activity: 40 min Wrap-up: 5 min

10. Enrichment/*Elaboration*

What enrichment activities are offered for students in this lesson (beyond what is taught)?	Conveying findings to the scientific community is a big part of the work of a scientist. An enrichment activity which fits with almost any lesson is for the students to be given the opportunity to write a short paragraph about the lesson to submit to a school newspaper or school science journal. (Don't have a school science journal? Start one!)

Gas Chromatography

What’s in my sample?

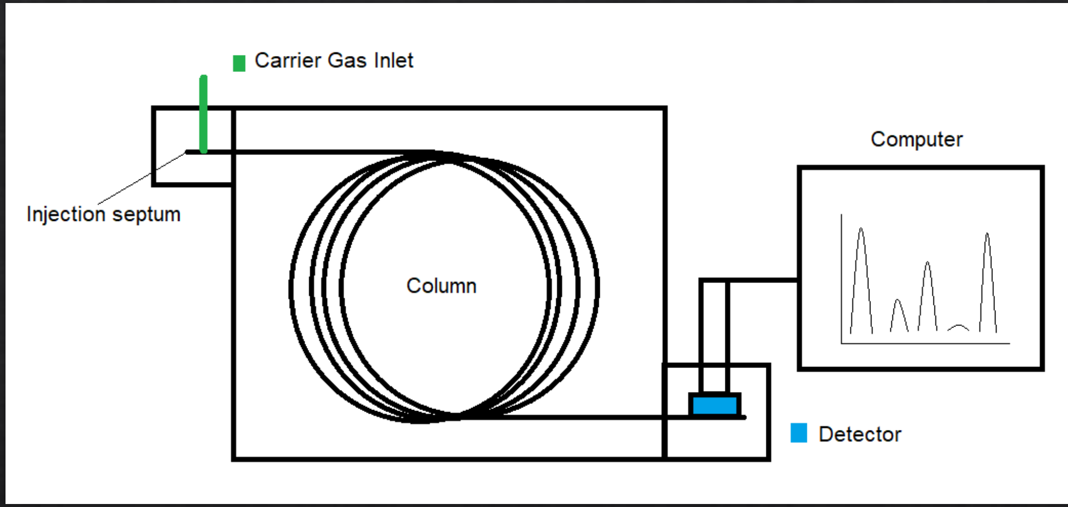
What is Gas Chromatography?

- Gas chromatography is a method for analyzing the chemical composition of a mixture or pure substance by vaporizing it and detecting it in the gas phase.

What can I do with Gas Chromatography?

- Gas Chromatography is used in many situations such as:
  - Drug tests
  - Criminal Investigations
  - The medical industry
  - The food industry
  - Detecting water quality

How does GC work?



- A liquid sample is injected in at the **injection septum**
- The sample is vaporized and carried through the column by the **carrier gas**
- The sample (now a gas) comes out of the column and it detected by the **detector**
- The detector relays the information to the computer software

How does a GC Work?

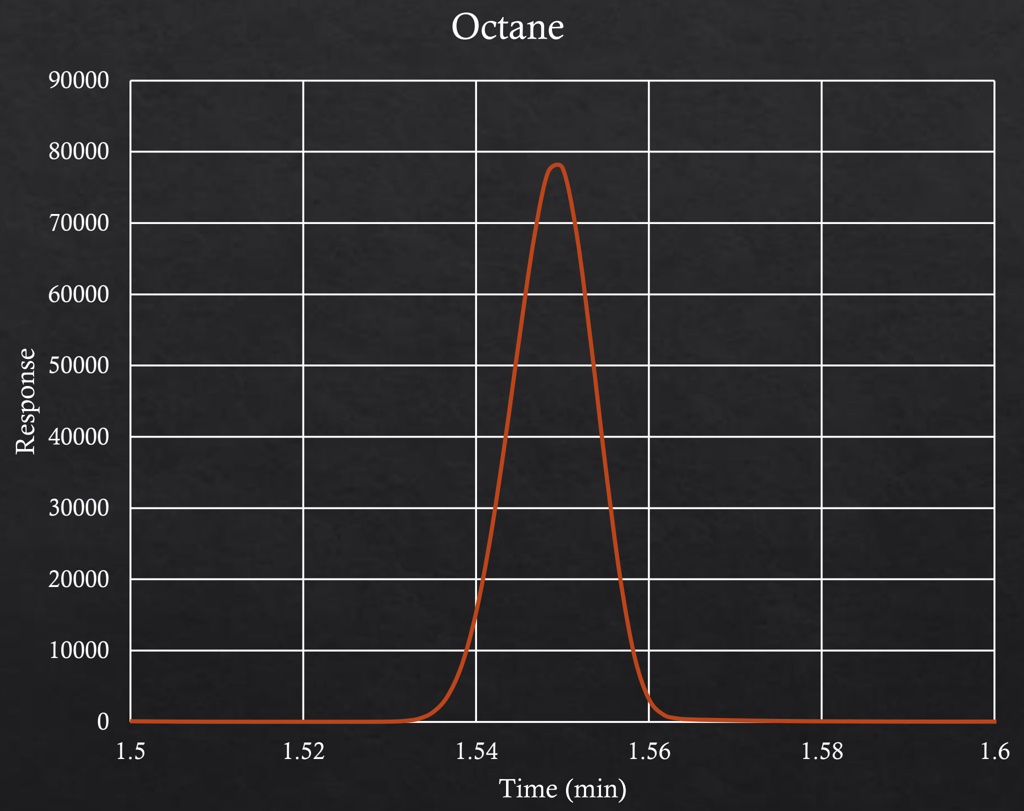
Detection of compounds as they come out of the column depends on some of the properties of a compound.

The difference in these properties will affect how long that particular compound will stay in the column (also called the **retention time**).

- Important Physical and Chemical Properties
  - Vapor pressure
  - Polarity
  - Amount of sample

What Does the Data Say?

- A Typical Gas Chromatogram is as on the left.
- The y-axis gives you detector response
- The x-axis gives you the retention time



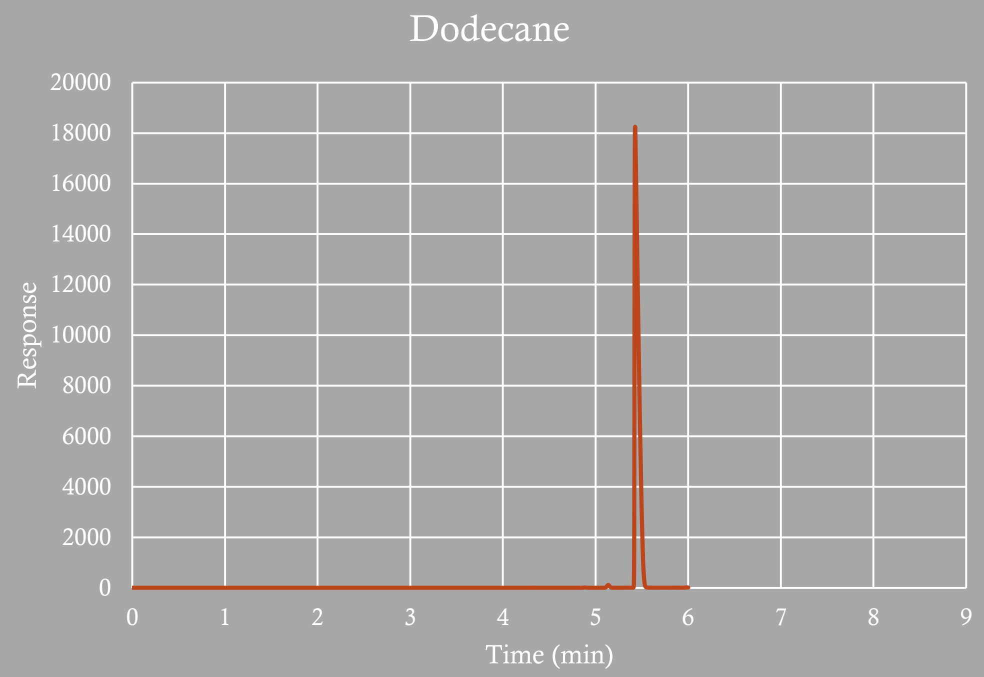
Analyzing Peaks and Identifying Molecules

- The key to analyzing a compound is knowing what to look for! Really, all the chromatogram tells you is how big of a response the detector gave off and how long it took for the sample to reach the detector.
- In order for you to know at what time a particular compound will elute, you will need to run standards with the known chemicals, and then compare them to the unknown chromatograph. Remember, **all** the other variables (like flowrate, how much of a sample is injected, etc.) need to be kept constant.

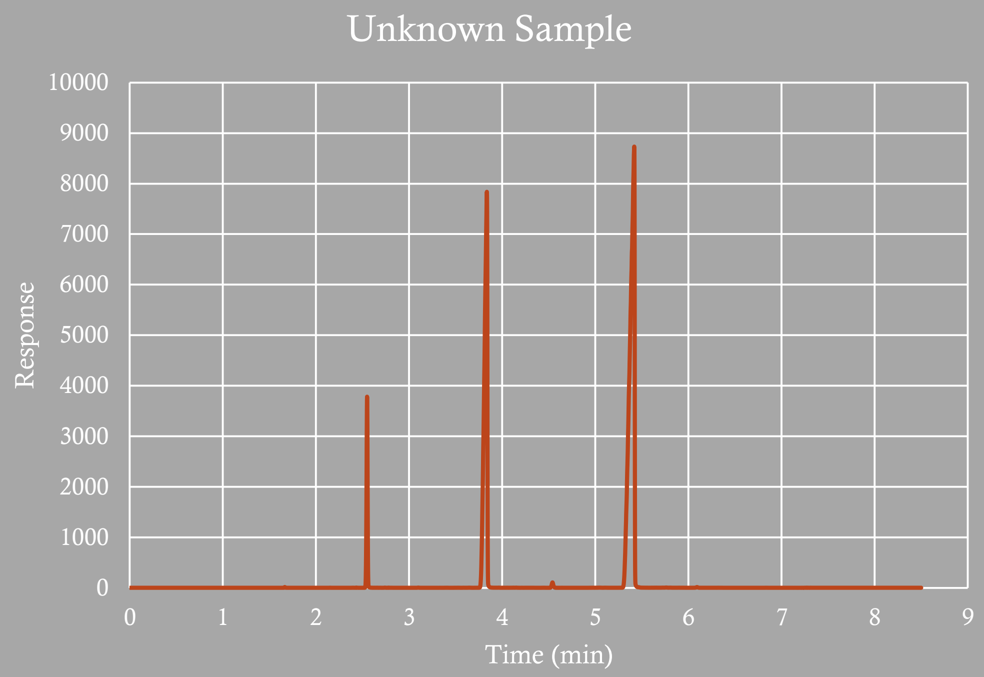
Does this Sample contain Dodecane?

Assuming the samples were run with all other variables and parameters remaining the same.

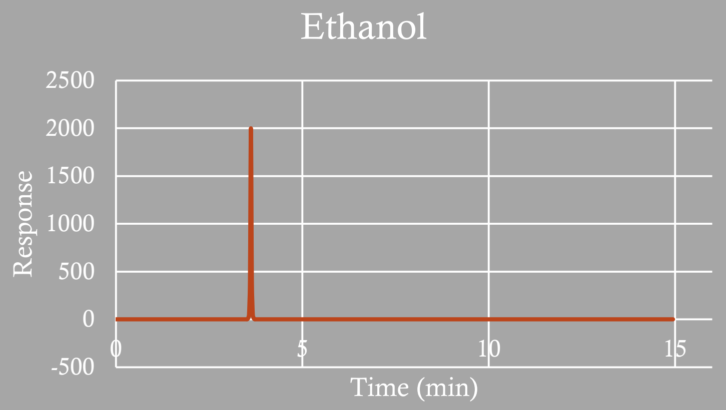
Chromatograph of Dodecane

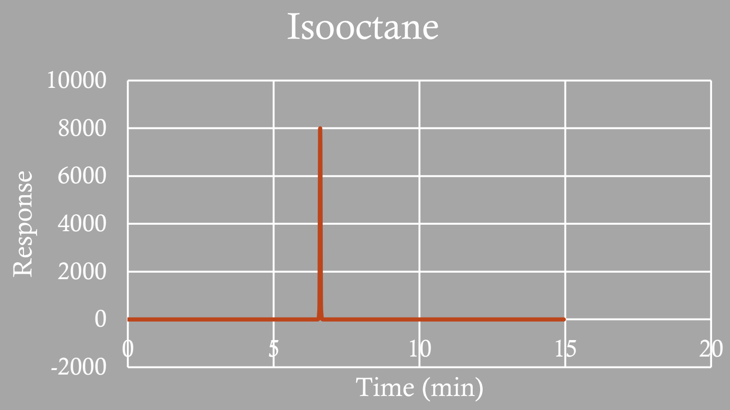


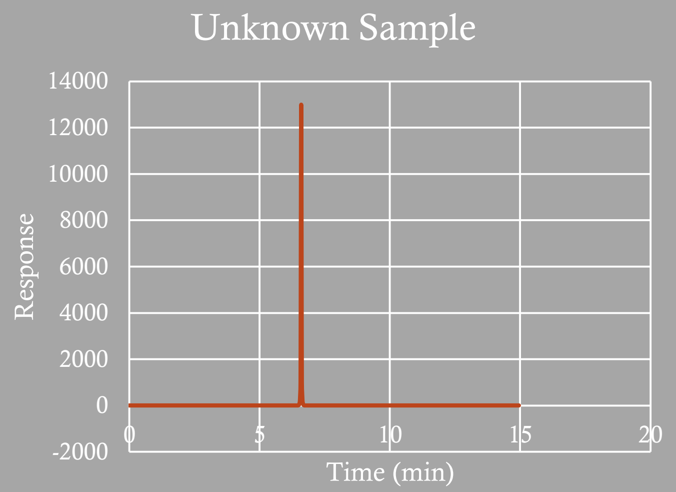
Chromatograph of Unknown

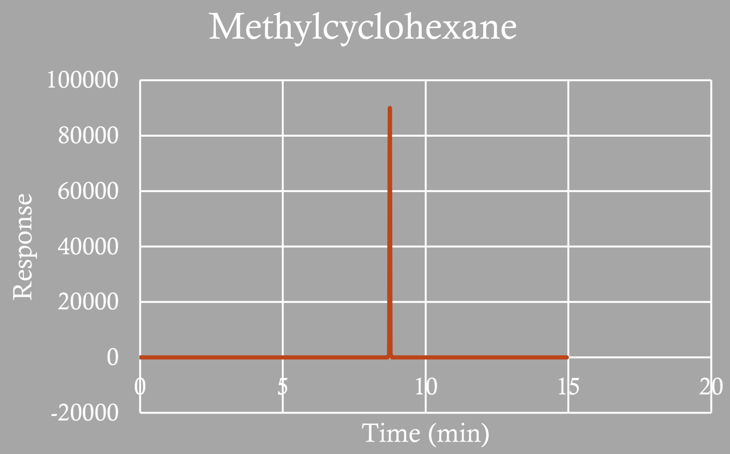


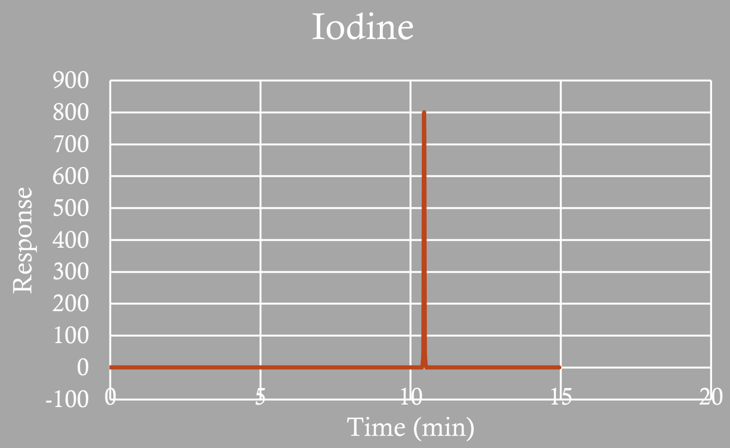
Now You Try!


Ethanol
Response
2500
2000
1500
1000
500
0
-500
0
5
10
15
Time (min)

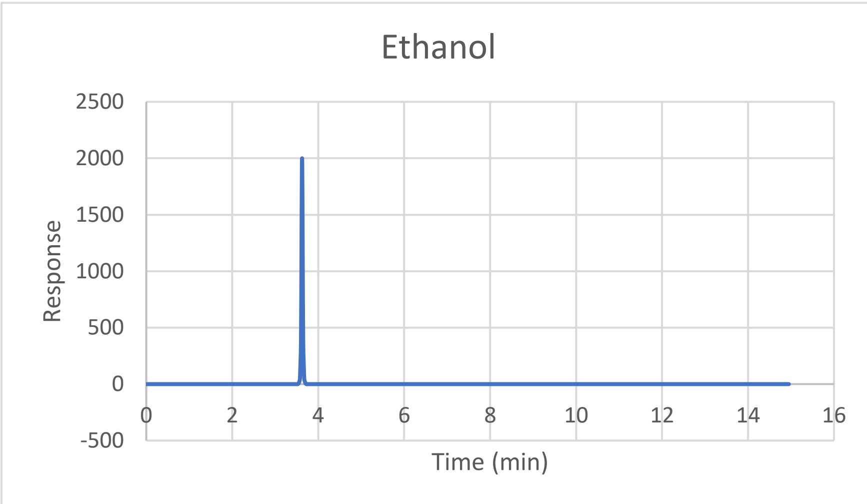

Isooctane
Response
10000
8000
6000
4000
2000
0
-2000
0
5
10
15
20
Time (min)

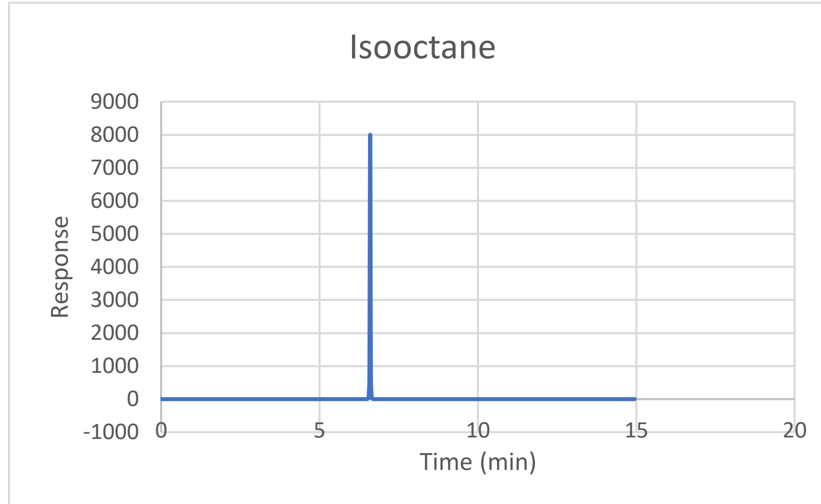

Unknown Sample
Response
14000
12000
10000
8000
6000
4000
2000
0
-2000
0
5
10
15
20
Time (min)

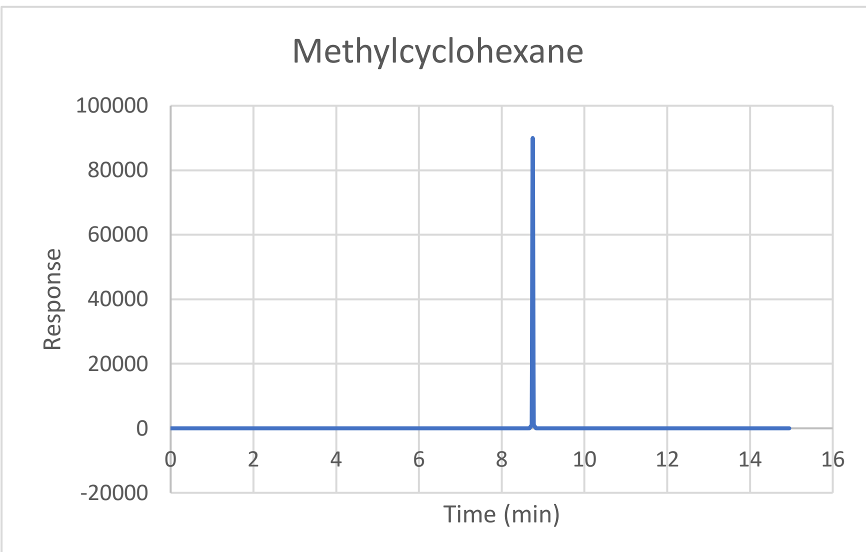

Methylcyclohexane
Response
100000
80000
60000
40000
20000
0
-20000
0
5
10
15
20
Time (min)

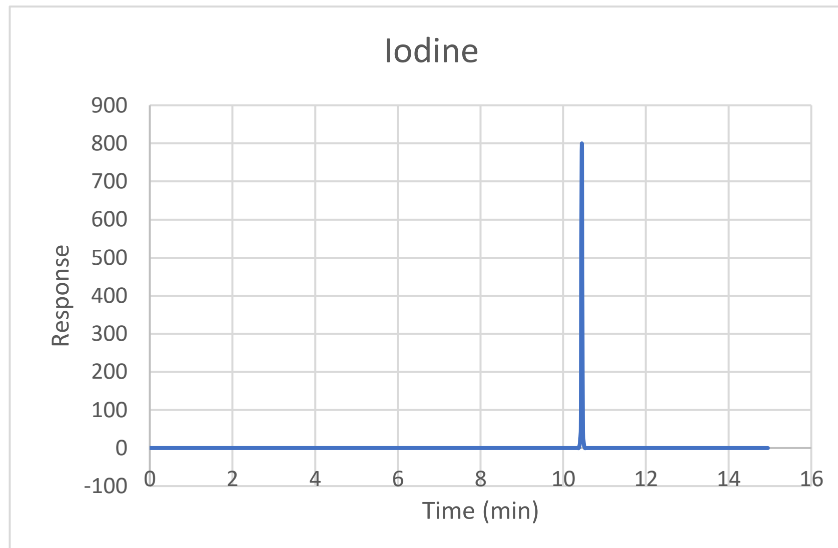

Iodine
Response
900
800
700
600
500
400
300
200
100
0
-100
0
5
10
15
20
Time (min)

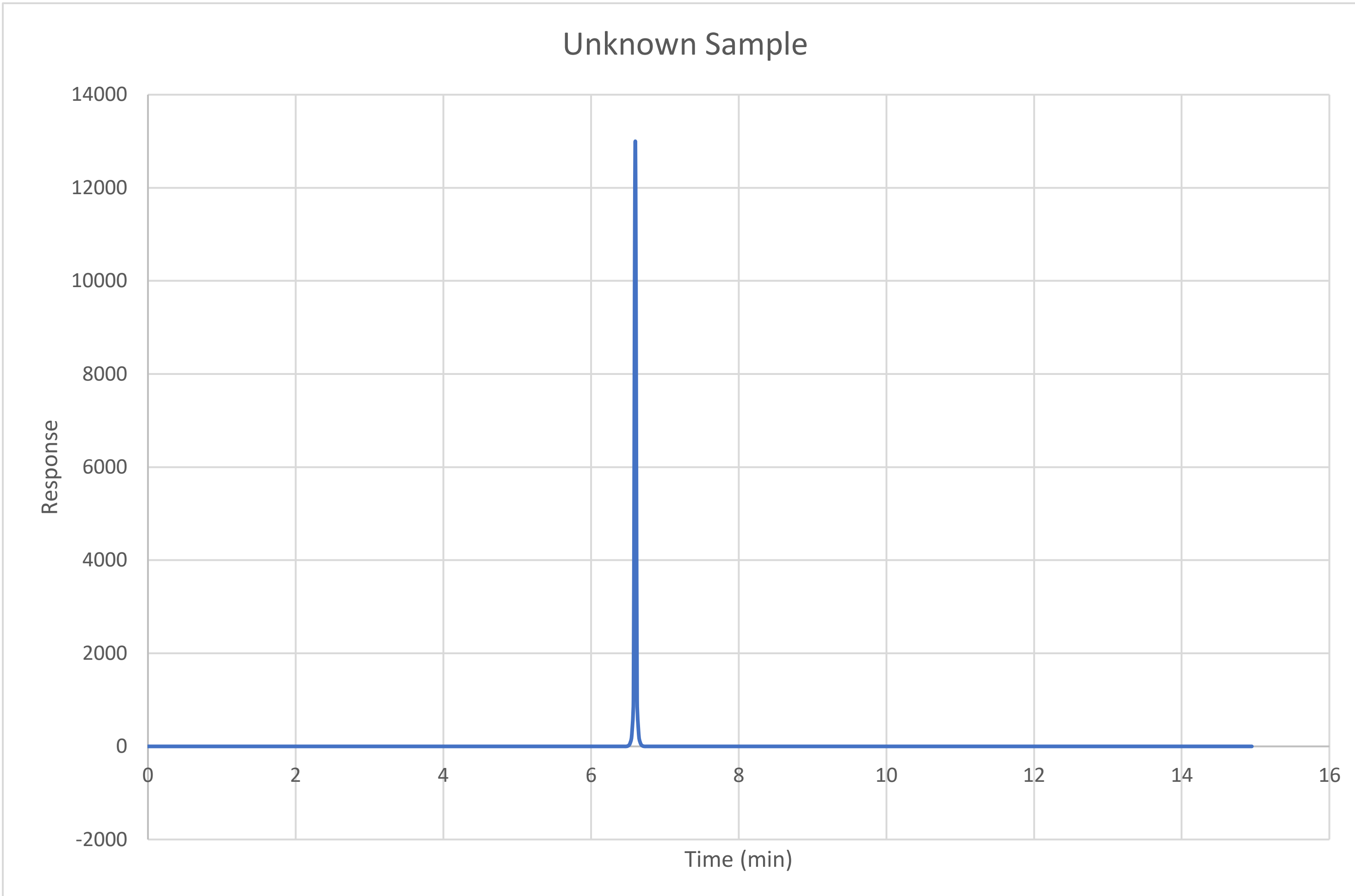
Gas Chromatography (How do I make sense of those peaks?)









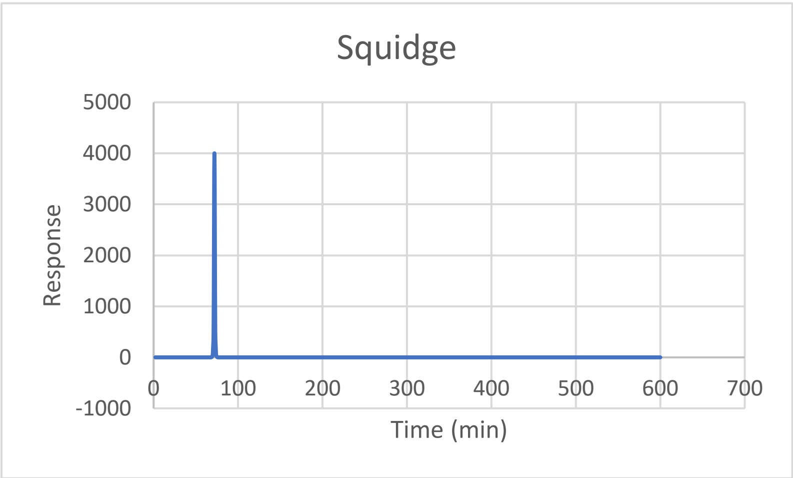


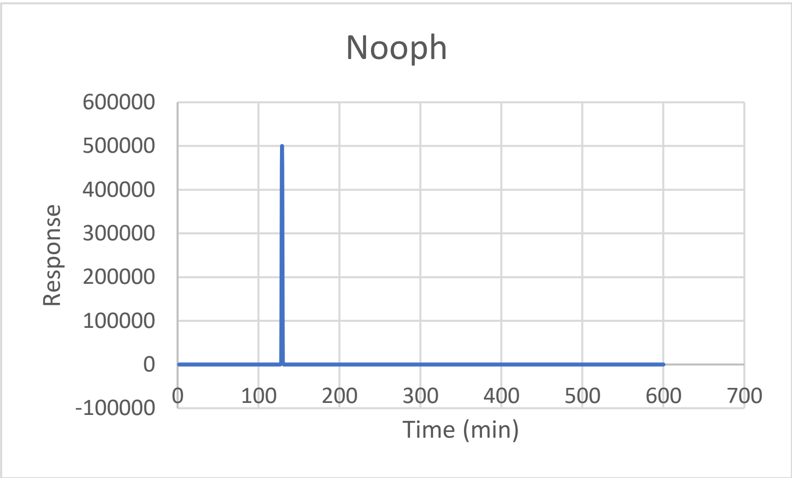
Which of the Chemicals whose chromatograms are on the first page is this unknown chromatogram of?

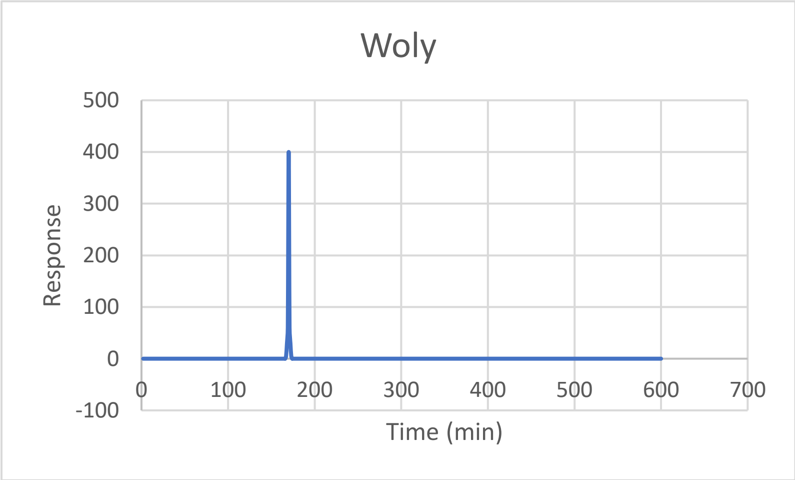
How do you know?

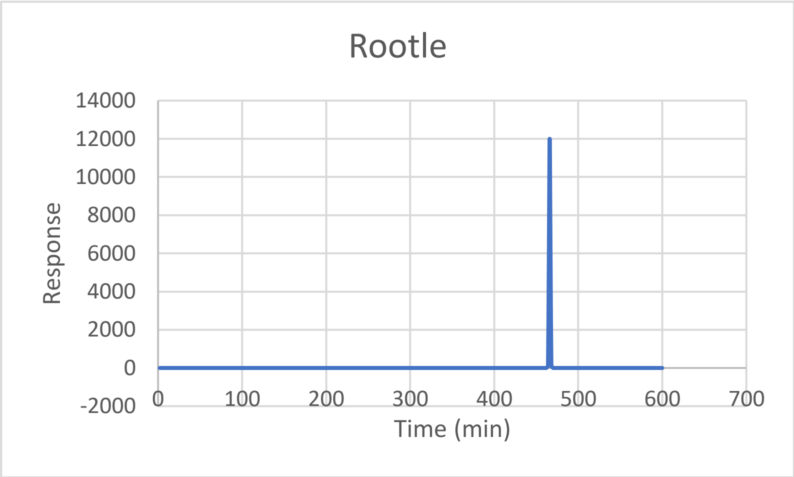
Try this one on your own!

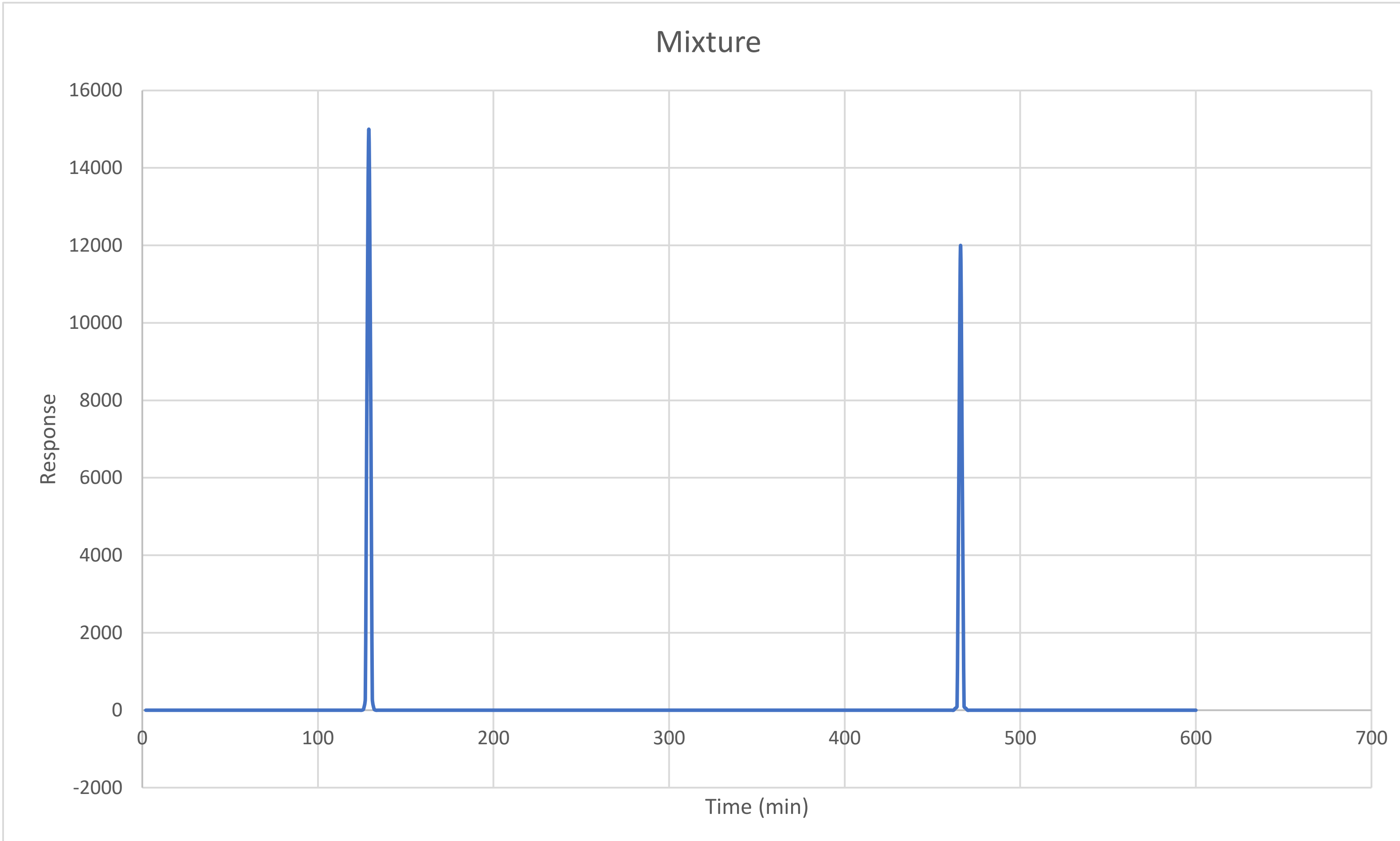
Figure out which chemicals are in the unknown mixture, given chromatograms of the chemicals Rootle, Nooph, Woly, and Squidge.











Which chemicals are contained in this mixture?

How do you know?

Meet the Microbes!

Streptomyces griseus

Where does he live: soil, decaying plant matter, and sometimes at the bottom of the sea in the sediments.

What makes him comfortable: He likes to live at high pHs.

What does he make: *S. griseus* produces the chemical geosmin, which is the chemical responsible for the earthy smell of soil!

Accomplishments: He is the official New Jersey State microbe; he also contributes to antibiotic production!

Microbe ID Procedure Plan

Names of Group Members

Instructions: Your job is to create a lab procedure for determining the identity of an unknown microbe if you were given the following materials:

-Data Corral Website

-Gas Chromatography

-the unknown bacteria specimen

-any chemical standards needed.

Your formal typed plan should contain the following sections:

1. An **Objective** statement telling what the main goal of the investigation is.
2. A **Materials** list including every material necessary for completing the investigation.
3. A **Procedure** telling each step of the investigation.
4. A **Paragraph** answering the following questions:
    a. How will you decide which chemical standards to run through the GC?
    b. Explain how analyzing chemicals relates to identifying bacteria specimens.
    c. How will you analyze the chromatographs to determine which bacteria type the unknown specimen is?

Rubric Made Using:
RubiStar (http://rubistar.4teachers.org)

Lab Report

Teacher Name: **Szott**

Student Name: ____

CATEGORY	4	3	2	1	0
Format	All sections are clearly labeled, there is a title, names of all group members, and font is Times New Roman 12 for the body of the report.	Sections are labeled, and overal format looks good, but some pieces are missing or not as specified.	Sections are labeled poorly and many pieces are missing or not as specified.	Sections are not labeled, and/or all other pieces are missing or not as specified.	N/A
Objective	Objective is clearly stated in at least one full sentence.	Objective is either clearly stated in an incomplete sentence, or unclear in a full sentence.	Objective is unclear.	N/A	Did not include
Material	All materials are listed.	1-2 items missing from materials list.	3-4 items missing from materials list.	5+ items missing from materials list.	Did not include
Procedure	Procedure is concise and clear; another student would be able to follow this procedure to the same end.	Procedure is clear, but not concise; there may be some trouble following it.	Procedure is not clear.	N/A	Did not include
Data	A chromatogram is inlcuded for each sample taken, including the unknown. Graphs are clearly labeled with titles and axes.	A chromatogram is included for each sample, but is not labeled clearly.	1-2 chromatograms missing, or none of the graphs are labeled at all.	2+ chromatograms missing.	Did not Include
Conclusions	Conclusions paragraph states the solution to the problem introduced in the objective and gives a clear explanation of how this was found.	Conclusions paragraphs answers the objective's problem, but explanation is unclear.	Conclusions paragraph answers the objective's problem, but there is no explanation.	Conclusions paragraph fails to answer the objective's problem, and there is little or no explanation.	Did not Include

Rubric Made Using:
RubiStar (http://rubistar.4teachers.org)

Microbe ID Plan

Teacher Name: **Szott**

Student Name: ____

CATEGORY	**4**	**3**	**2**	**1**	**0**
Format	All sections are labeled clearly, Title and group members are listed, Font is Times New Roman size 12.	All sections are labeled, but one of the other pieces is either missing or not as specified.	All sections are labeled, but several other pieces are either missing or not as specified.	Sections are not labeled.	N/A
Objective	Objective is clearly stated in at least one full sentence.	Objective is stated, but is not in a full sentence.	Objective is not clear.	N/A	Did not Include
Materials	All materials are listed.	1-2 items are missing from list.	3-4 items are missing from list.	5+ items are missing from list.	Did not Include
Procedure	Procedure is concise and clear; it explains exactly what a scientist should do step by step.	Procedure is clear, but incomplete.	Procedure is complete but unclear.	Procedure is incomplete and unclear.	Did not Include
Paragraph	Paragraph answers all questions clearly and thoroughly.	Paragraphs answers most or half of the questions clearly and thoroughly; all questions are addressed.	Paragraph at least addresses all questions, even if unclear, or addresses 3 out of 4 very clearly.	Paragraph does not address all questions and is not clear.	Did not Include

teacher home
