CHEMISTRY LABS (OTP PROJECT)

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Chemistry labs (OTP Project)

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Detailed Licensing

Licensing

*A detailed breakdown of this resource's licensing can be found in **Back Matter/Detailed Licensing**.*

CHAPTER OVERVIEW

1: Exp 1- Density

1.1: Video Links

Lab Experiments (Write protocols and perform experiments based on these):

1. Weighing

2. Measuring Volume

3. Making Sugar Solutions

4. Determining Density

5. Layering Solutions

Data analysis and calculations (Use these if you need help with your data and calculations)

1. Measurements

2. Significant figures

1.2: Experimental Protocol and Tables (Prelab)

The prelab must include Experimental Protocol, Chemical Table and Equipment Table.

The lab report requires all sections (including prelab sections) to be completed in one document.

Experimental Protocol

(Analysis) Watch the experiment videos. Take notes on the protocol. Stop the video and re-watch as necessary to acquire the details of the procedure. Write out the protocol for each part of the experiment. (It can be written in sequential steps. Complete sentences are not necessary.) This is the protocol you will follow, so be detailed.

Chemical Table

(Representation) Prepare your chemical table including the materials you will use in the experiment. Here is a general template that you may use.

Chemical Name	Chemical Formula	Molar Mass (g/mol)	Hazards	reference	PPE
Sodium Chloride	**NaCl**	**58.5**	**Skin irritation**	**https://fscimage.fishersci.com/msds/21105.htm**	

Equipment Table

(Analysis) Identify the equipment (type AND size) needed for the experiment and include the name and an image of each. Be sure to describe the equipment, how to use it, and why it is suitable for this use.

Equipment Name	Equipment Picture	Intended Purpose

1.3: Data and Analysis

Data Collection

(Acquiring competencies) Following your detailed protocol based on the videos, perform all the experiments. Record your observations and take pictures of your key steps in the process. Your observations and images need to be incorporated in your data section and this section should be as detailed as possible as you will use this information to complete your discussion.

Data Processing

1. (Manipulation) Calculate the density of each sugar water solution.
2. (Assumptions and Analysis) Fill in the following table using the observations and data from your experiments.

Assumptions made	Testing the assumption	If assumptions are wrong ...
The distilled water is pure	Evaporate it and check for residue	The density would change depending on the density of the contaminant
The 2 drops of food coloring don't change the density	Check density of the solution before and after the addition of the food coloring	
All the sugar that is added to the water dissolves		The solutions will have a lower density

1.4: Discussion

Discussion

Write a minimum one-page (12 font, single spaced) discussion on the experiment conducted this week. Address **at least one question in each category** as fully as possible integrating the collected data, providing explanations for the observed trends, and evaluating whether your original assumptions about the experiment were validated by the results. **The assignment will be graded on completeness, clarity of the explanations and the meaningful integration of the collected and calculated data.** Correct grammar and appropriate format for the chemical formulae and chemical reactions is expected. **You may use the outline included at the end of this document on how to build your essay to address each category.**

1. (Representation) Describe the components needed to correctly express a measurement using your recorded masses and volumes.
2. (Analysis) Identify the number of significant figures in all your recorded measurements. Describe what process you used to decide how many numbers were appropriate.
3. (Existing knowledge, research, and views) Classify mass, volume and density as intensive or extensive properties. Provide justification for your selections.
4. (Design process) Warm water was used to make the sugar water solutions. Provide at least one argument for why warm water is preferred for making the solutions.
5. (Design process) A drop of food coloring was added to each solution. Provide an explanation for why this was necessary and suggest an alternative for the use of the food coloring.
6. (Manipulation) Describe how you calculated the density of the solutions. Use one of your calculations to demonstrate the process.
7. (Analysis) How many significant figures will your calculated density have? Explain how you arrived at your conclusion.
8. (Analysis) Consider the components of your solutions, then evaluate which of those components will contribute meaningfully to the density of the solution. Use your experiment and calculated values as supporting evidence.
9. (Analysis) Compare the density values calculated using the three separate measurements for each solution. Provide an explanation for the observed differences and/or similarities.
10. (Analysis) Compare your density values to the values obtained by your team members. Provide an explanation for the observed differences and/or similarities.
11. (Experiment design) When layering the solutions, a clean and dry pipette was required to manipulate extract each layer. Provide at least one justification for this requirement.
12. (Experiment design) The solutions were layered starting with the densest solution on the bottom. Provide a strong argument why this order was required.
13. (Assumptions and limitations) Consider what would happen if you layered the solutions in a different order. Provide a brief description of what you predicted or observed and use your knowledge of density to support your prediction/observation.
14. (Experiment design) Propose another experiment using chemicals from your home that will result in the creation of a density column. You may carry out the experiment and submit the picture for bonus points.

Recommended discussion outline:

The properties of matter that we studied in this experiment are … and can be classified as ...

In this experiment, we represented …..

An alternate experiment that would result in a similar outcome would be ….

When calculating density, we use … and we perform the following calculation ….

The density values for the solutions are ….

In this experiment we assumed ....

The purpose of the experiment was … By performing this experiment, I learned ...

CHAPTER OVERVIEW

2: Exp 2- Crystal Growth part 1

2.1: Video Links

Lab experiments (Write protocols and perform experiments based on these):

1. Making Saturated Alum Solution

2. Growing Seed Crystals

3. Seed Crystal Maintenance

Demonstration (Watch optional video for additional information on crystal growth)

1. Other crystal growing demonstrations

Data analysis and interpretation (Use these if you need help with your data and discussion)

1. Solubility

2. Crystallization

2.2: Experimental Protocol and Tables (Prelab)

The prelab must include Experimental Protocol, Chemical Table and Equipment Table.

The lab report requires all sections (including prelab sections) to be completed in one document.

Experimental Protocol (Prelab)

(Analysis) Watch the experiment videos. Take notes on the protocol. Stop the video and re-watch as necessary to acquire the details of the procedure. Write out the protocol for each part of the experiment. (It can be written in sequential steps. Complete sentences are not necessary.) This is the protocol you will follow, so be detailed.

Chemical Table (Prelab)

(Representation) Prepare your chemical table including the materials you will use in the experiment. Here is a general template that you may use.

Chemical Name	Chemical Formula	Molar Mass (g/mol)	Hazards	reference	PPE
Sodium Chloride	**NaCl**	**58.5**	**Skin irritation**	**https://fscimage.fishersci.com/msds/21105.htm**	

Equipment Table (Prelab)

(Analysis) Identify the equipment (type AND size) needed for the experiment and include the name and an image of each. Be sure to describe the equipment, how to use it, and why it is suitable for this use.

Equipment Name	Equipment Picture	Intended Purpose

2.3: Data and Analysis

Data Collection (Data and Analysis)

(Acquiring competencies) Following your detailed protocol based on the videos, perform all the experiments. Record your observations and take pictures of your key steps in the process. Your observations and images need to be incorporated in your data section and this section should be as detailed as possible as you will use this information to complete your discussion.

Data Processing (Data and Analysis)

1. (Interpretation) Identify the changes that were observed in this experiment. Classify the changes as physical or chemical.
2. (Representation) Create a table that includes at least the following information from you and your team members. You may include additional information (ex. your room temperature, cover on/off, etc.) that you think is relevant.

Student Name	Volume of hot water (mL)	Temperature of hot water(°C)	Mass of alum (g)	Time until first crystal appeared	Number of crystals	Shape of crystals

3. (Interpretation) Identify at least one aspect that all the experiments were similar in, and one aspect that the experiments differed in.
4. (Assumptions and Analysis) Fill in the following table using the observations and data from your experiments.

Assumptions made	Testing the assumption	If assumptions are wrong ...
All solids dissolve in water.	Dissolve multiple solids in water.	Some will dissolve and some will not.
The distilled water is pure.	Evaporate it and check for residue.	

2.4: Discussion

Discussion

Write a minimum one-page (12 font, single spaced) discussion on the experiment conducted this week. Address **at least one question in each category** as fully as possible integrating the collected data, providing explanations for the observed trends and evaluating whether your original assumptions about the experiment were validated by the results. **The assignment will be graded on completeness, clarity of the explanations and the meaningful integration of the collected and calculated data.** Correct grammar and appropriate format for the chemical formulae and chemical reactions is expected. **You may use the outline included at the end of this document on how to build your essay to address each category.**

1. (Existing knowledge, research and views) Describe the contents of a solution and indicate the purpose for each.
2. (Existing knowledge, research and views) Describe at least one methods that you could use to determine if a substance is soluble in water.
3. (Existing knowledge, research, and views) Describe the difference between saturated and unsaturated solutions.
4. (Analysis) Consider the steps involved in preparing the saturated alum solution. Classify the solution as saturated or unsaturated in each step and explain your choice.
5. (Analysis) Provide at least one reason for using hot water to dissolve the alum.
6. (Analysis) Provide at least one supported argument for waiting for the solution to cool to room temperature before filtration.
7. (Lab skill) Describe the filtration process in as much detail as you deem necessary. Provide an explanation for the necessity of each step involved.
8. (Existing knowledge, research and views) Solids can be crystalline or amorphous. Describe at least 3 characteristics of crystalline solids.
9. (Analysis) Describe what happens with the saturated alum solution that causes the appearance and growth of the seed crystals.
10. (Lab skill) Describe the process of monitoring and maintaining the seed crystal.
11. (Analysis) Predict what would happen, if you left all your little crystals in the Petri dish instead of transferring a few into the saturated alum solution, and provide a supported argument for your prediction.
12. (Lab skill) Describe what kind of crystals you would select to start your seed crystal growth and what method you would use to transfer the selected crystal from one dish to another.
13. (Experiment design) Using your experience growing the alum seed crystals, propose a protocol for growing crystals from other compounds, such as copper(II) sulfate, sucrose, sodium chloride, etc. Pick one compound to develop your protocol for.
14. (Existing knowledge, research and views) Growing crystals is visually impressive and useful. Describe at least one application for growing crystals.

Recommended outline

Solution are composed of ……and ……. In our experiment the solvent is …… and the solute is ……. We know that we have a solution because …… The solution is saturated when ……. and it is unsaturated when …….. Solubility depends on temperature. At higher temperature, alum …….

In the process of making the alum solution we started with hot water because ……... and we cooled the solution before filtration because …… The steps required for filtration are …… In the first step it is important to …… In the second step ……. (continue for each step).

Crystals form when ……. The main characteristics of crystals are ……. Seed crystals should be …….. and of an approximate size of …… Seed crystals are necessary for …….. When monitoring the crystal growth

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CHAPTER OVERVIEW

3: Exp 3- Crystal Growth part 2 (Growing the Large Single Crystal)

3.1: Video Links

Lab experiments (Write protocols and perform experiments based on these):

1. Growing Large Single Crystals

2. Crystal Maintenance

Data analysis and interpretation (Use these if you need help with your data and discussion)

1. Crystallization

The prelab must include Experimental Protocol, Chemical Table and Equipment Table.

The lab report requires all sections (including prelab sections) to be completed in one document.

3.2: Experimental Protocol and Tables (Prelab)

Experimental Protocol (Prelab)

(Analysis) Watch the experiment videos. Take notes on the protocol. Stop the video and re-watch as necessary to acquire the details of the procedure. Write out the protocol for each part of the experiment. (It can be written in sequential steps. Complete sentences are not necessary.) This is the protocol you will follow, so be detailed.

Chemical Table (Prelab)

(Representation) Prepare your chemical table including the materials you will use in the experiment. Here is a general template that you may use.

Chemical Name	Chemical Formula	Molar Mass (g/mol)	Hazards	reference	PPE
Sodium Chloride	**NaCl**	**58.5**	**Skin irritation**	**https://fscimage.fishersci.com/msds/21105.htm**	

Equipment Table (Prelab)

(Analysis) Identify the equipment (type AND size) needed for the experiment and include the name and an image of each. Be sure to describe the equipment, how to use it, and why it is suitable for this use.

Equipment Name	Equipment Picture	Intended Purpose

3.3: Data and Analysis

Data Collection

(Acquiring competencies) Following your detailed protocol based on the videos, perform all the experiments. Record your observations and take pictures of your key steps in the process. Your observations and images need to be incorporated in your data section and this section should be as detailed as possible as you will use this information to complete your discussion.

Data Processing

1. (Representation) Complete the following table with the relevant information from you and your team members. (HINT: Select the longest dimension in cm for the size.)

Student name	Seed crystal 1 size (cm)	Seed crystal 2 size (cm)	Seed crystal 1 mass (g)	Seed crystal 2 mass (g)	Seed crystal 1 picture	Seed crystal 2 picture	Crystal 1 picture at the end of the week	Crystal 2 picture at the end of the week

2. (Interpretation) Identify at least one aspect that all the experiments were similar in, and one aspect that the experiments differed in.
3. (Assumptions and Analysis) Fill in the following table using the observations and data from your experiments.

Assumptions made	Testing the assumption	If assumptions are wrong ...
Our alum grow solution is saturated.	Submerge the crystal in the grow solution.	If it is unsaturated, the crystal will disappear. If it is very supersaturated there will be other alum crystals forming.
The string will not dissolve in the solution.	Submerge the string in the grow solution.	

3.4: Discussion

Write a minimum one-page (12 font, single spaced) discussion on the experiment conducted this week. Address **at least one question in each category** as fully as possible integrating the collected data, providing explanations for the observed trends and evaluating whether your original assumptions about the experiment were validated by the results. **The assignment will be graded on completeness, clarity of the explanations and the meaningful integration of the collected and calculated data.** Correct grammar and appropriate format for the chemical formulae and chemical reactions is expected. **You may use the outline included at the end of this document on how to build your essay to address each category.**

1. (Existing knowledge, research, and views) Describe the difference between saturated and supersaturated solutions.
2. (Existing knowledge, research and views) Classify alum as an ionic or molecular compound and describe the crystal structure of alum.
3. (Lab skill) Describe the process involved in starting the crystal growth project and provide a purpose for each step.
4. (Analysis) Describe what characteristics of the seed crystals you considered when selecting the most suitable crystals for this project. Provide at least one supported argument to justify your selection process.
5. (Lab skill) Estimate the approximate size of a seed crystal that would be useful to grow a large single crystal from.
6. (Analysis) Provide at least one supported argument for using a saturated solution to grow the single crystal from the seed crystal.
7. (Assumptions) A seed crystal is submerged in a solution and disappears. What assumption can we make about the solution?
8. (Analysis) Describe what happens with the saturated alum solution that causes the growth of the single crystals from the seed crystals.
9. (Analysis) Provide at least two supported arguments for starting the crystal project with two seed crystals submerged in the grow solution.
10. (Analysis) Your seed crystal should be suspended by a thread in the grow solution, instead of remaining in the Petri dish. Provide a supported argument for why this transition is necessary.
11. (Lab skill) Describe the process of monitoring and maintaining the large single crystal.
12. (Assumptions) Each time the alum single crystal is maintained, it needs to be rinsed thoroughly with distilled water before being placed into the filtered grow solution. What assumption are we making about the crystal that makes this approach necessary?
13. (Analysis) Alum is soluble in water. Why doesn't the crystal dissolve when it is washed with water?

Recommended outline

Alum is a(n) …….. compound which means that in the solid state ……. are held together by …….. and form …… structures.

A solution is saturated when ……. And it is supersaturated when ……. When growing our crystal starting with the alum seed crystal, we could tell that the solution was saturated when …….. and supersaturated when …….

Setting up for the growing of the large single crystal from seed requires the following steps: ……. In the first step we …… because…….. (continue for each step). A suitable seed crystal is one that …… and has approximately ……. size. These are important considerations because ……

When submerging the seed crystal in the grow solution, we want the grow solution to be …….. because ……. If our crystal were to disappear, we would assume ……. If there are lots of crystals growing in our solution, we would assume ……

When a saturated solution is left outside, the water will…….. and this will cause the solution to become ……. These changes will cause the crystal ……. We use two seed crystals for this experiment because …….

When growing the large crystal, we suspend the seed crystal from a thread in the middle of the grow solution because …… When monitoring the growth of single crystals we look for …… and if …… then ……. We are rinsing the crystals each time we extract them from the solution based on the assumption that the crystals will ……. which will result in …….. We are able to rinse our crystals in distilled water without them disappearing because ……..

CHAPTER OVERVIEW

4: Exp 4- Emission Spectra

4.1: Video Links

Lab Experiments (Write protocols and perform experiments based on these):

1. Building a Spectrometer

Data analysis and calculations (Use these if you need help with your data and calculations)

1. Electromagnetic Radiation

2. Energy of Electromagnetic Radiation

3. Bohr Model

Topic application videos (Watch videos and take notes):

1. Sources of Light
2. A different Kind of Firework
3. Other Sources of Energy
4. Sparklers

Additional information (For the Comic-book lovers)

1. What Color is the Sun?

4.2: Experimental Protocol and Tables (Prelab)

The prelab must include Experimental Protocol, Chemical Table and Equipment Table.

The lab report requires all sections (including prelab sections) to be completed in one document.

Experimental Protocol

(Analysis) Watch the experiment videos. Take notes on the protocol. Stop the video and re-watch as necessary to acquire the details of the procedure. Write out the protocol for each part of the experiment. (It can be written in sequential steps. Complete sentences are not necessary.) This is the protocol you will follow, so be detailed.

Chemical Table

(Representation) Prepare your chemical table including the materials you will use in the experiment. Here is a general template that you may use.

Chemical Name	Chemical Formula	Molar Mass (g/mol)	Hazards	reference	PPE
Sodium Chloride	**NaCl**	**58.5**	**Skin irritation**	https://fscimage.fishersci.com/msds/21105.htm	

Equipment Table

(Analysis) Identify the equipment (type AND size) needed for the experiment and include the name and an image of each. Be sure to describe the equipment, how to use it, and why it is suitable for this use.

Equipment Name	Equipment Picture	Intended Purpose

4.3: Data and Analysis

Data Collection

(Acquiring competencies) Following your detailed protocol based on the videos, perform all the experiments. Record your observations and take pictures of your key steps in the process. Your observations and images need to be incorporated in your data section and this section should be as detailed as possible as you will use this information to complete your discussion.

Light Source	Photo/Drawing/Description of the spectrum	Wavelength range of the spectrum
Sun		400-800 nm

Data Processing

1. (Representation) Identify 3 elements that are used to give color to sparklers and write their electron configurations in the following formats:

1. Full electron configuration by filling order:
2. Full electron configuration by ***spdf*** notation:
3. Noble gas electron configuration by filling order:
4. Noble gas electron configuration by ***spdf*** notation:

2. (Manipulation) The strongest emission line for helium is at 420 nm. Write the formula for determining the frequency of this light and show your stepwise calculations with the correct units.
3. (Manipulation) The strongest emission line for helium is at 420 nm. Write the formula for determining the energy of this light and show your stepwise calculations with the correct units.
4. (Existing knowledge, research, and views) Describe why some spectra have the full range of colors while some only give a few colored lines.
5. (Assumptions and Analysis) Fill in the following table using the observations and data from your experiments.

Assumptions made	Testing the assumption	If assumptions are wrong ...
The distilled water is pure	Evaporate it and check for residue	The density would change depending on the density of the contaminant
When we look into the spectrophotometer we only see the light we are aiming at.	Look at the same light source during the day and during the night.	

4.4: Discussion

Discussion

Write a minimum one-page (12 font, single spaced) discussion on the experiment conducted this week. Address **at least one question in each category** as fully as possible integrating the collected data, providing explanations for the observed trends, and evaluating whether your original assumptions about the experiment were validated by the results. **The assignment will be graded on completeness, clarity of the explanations and the meaningful integration of the collected and calculated data.** Correct grammar and appropriate format for the chemical formulae and chemical reactions is expected. **You may use the outline included at the end of this document on how to build your essay to address each category.**

1. (Existing knowledge, research, and views) Define electromagnetic radiation in your own words and describe what a spectrophotometer does with it.
2. (Experimental design) Propose at least one more item that you could use instead of a CD to build your spectrophotometer and describe why it would be suitable.
3. (Analysis) Provide an argument for why the slit through which light enters the spectrophotometer needs to be very narrow.
4. (Analysis) Provide an argument for why it is important to cover all the slits and corners on the box before using the spectrophotometer.
5. (Analysis) Compare the spectra of the varies light sources you looked at. Identify at least one difference and at least one similarity among them.
6. (Existing knowledge, research, and views) Describe the color of the Sun and provide an argument for why in the USA children color their Sun yellow.
7. (Analysis) Identify the wavelength for yellow. Provide an explanation for choosing a number or a range.
8. (Analysis) Provide an argument for why a shirt would appear yellow. (HINT: Is the color of objects emitted or reflected?)
9. (Analysis) Provide an argument for why a lightbulb would appear yellow. (HINT: Is the color of light emitted or reflected?)
10. (Existing knowledge, research, and views) Each element has a unique spectrum that identifies it, like a fingerprint for humans. Describe how you would use your spectrophotometer to identify an element.
11. (Existing knowledge, research, and views) Each element has a unique spectrum that identifies it, like a fingerprint for humans. Describe what causes these emission spectra.
12. (Existing knowledge, research, and views) Describe how sparklers work. Provide as much detail as you deem necessary.
13. (Existing knowledge, research, and views) Identify the colors that can be produced by sparklers. Indicate the elements responsible for each color.
14. (Existing knowledge, research, and views) Using the videos as your reference, describe at least two applications for converting energy into light in as much detail as you deem necessary.

Recommended discussion outline:

Electromagnetic radiation is …. A spectrophotometer is an instrument that works by ...

The parts of the spectrophotometer are … The purpose of the CD in the spectrophotometer is …. and it can be replaced with a …. because …. If the slit was widened, it would... If the inside of the box wasn't dark, it would …. If the peephole wasn't looking directly at the CD, we would see ...

I tested the following light sources: ... The difference between the collected spectra is …., and that is due to …. The similarity between the collected spectra is …., and that is due to ….

The color of the Sun is … and we observe it as … because …

The difference between the perceived color of objects and light is …

An element can produce a unique combination of wavelengths when it is … and then …

In this experiment we assumed ....

The purpose of the experiment was … By performing this experiment, I learned ...

CHAPTER OVERVIEW

5: Exp 5- Separation of Mixtures

5.1: Video Links

Lab Experiments (Write protocols and perform experiments based on these):

1. Making Salt and Sand Mixture

2. Separating Salt from Sand

3. Recovering Salt and Sand

Data analysis and calculations (Use these if you need help with your data and calculations)

1. Percent Composition

5.2: Experimental Protocol and Tables (Prelab)

The prelab must include Experimental Protocol, Chemical Table and Equipment Table.

The lab report requires all sections (including prelab sections) to be completed in one document.

Experimental Protocol

(Analysis) Watch the experiment videos. Take notes on the protocol. Stop the video and re-watch as necessary to acquire the details of the procedure. Write out the protocol for each part of the experiment. (It can be written in sequential steps. Complete sentences are not necessary.) This is the protocol you will follow, so be detailed.

Chemical Table

(Representation) Prepare your chemical table including the materials you will use in the experiment. Here is a general template that you may use.

Chemical Name	Chemical Formula	Molar Mass (g/mol)	Hazards	reference	PPE
Sodium Chloride	**NaCl**	**58.5**	**Skin irritation**	https://fscimage.fishersci.com/msds/21105.htm	

Equipment Table

(Analysis) Identify the equipment (type AND size) needed for the experiment and include the name and an image of each. Be sure to describe the equipment, how to use it, and why it is suitable for this use.

Equipment Name	Equipment Picture	Intended Purpose

5.3: Data and Analysis

Data Collection

(Acquiring competencies) Following your detailed protocol based on the videos, perform all the experiments. Record your observations and take pictures of your key steps in the process. Your observations and images need to be incorporated in your data section and this section should be as detailed as possible as you will use this information to complete your discussion.

Data Processing

1. (Representation) Using your collected measurements, fill out the table below.

Substance	Before separation (g)	After separation (g)	Percent recovery (after/before×100%) (%)	Cause for change in mass
Salt (NaCl)				
Sand (SiO2)				
Total				

2. (Manipulation) Calculate the percent composition of the mixture (% NaCl and % sand) using the original amounts of each substance. Show your stepwise calculation with the appropriate units.
3. (Manipulation) Calculate the percent composition of the mixture (% NaCl and % sand) using the recovered amounts of each substance. Show your stepwise calculation with the appropriate units.
4. (Manipulation) Using the total mass of the mixture before and after the separation, calculate the % recovery. Show your stepwise calculation with the appropriate units.
5. (Assumptions and Analysis) Fill in the following table using the observations and data from your experiments.

Assumptions made	Testing the assumption	If assumptions are wrong ...
The distilled water is pure	Evaporate it and check for residue	The density would change depending on the density of the contaminant
Our balance is accurate		

5.4: Discussion

Discussion

Write a minimum one-page (12 font, single spaced) discussion on the experiment conducted this week. Address **at least one question in each category** as fully as possible integrating the collected data, providing explanations for the observed trends, and evaluating whether your original assumptions about the experiment were validated by the results. **The assignment will be graded on completeness, clarity of the explanations and the meaningful integration of the collected and calculated data.** Correct grammar and appropriate format for the chemical formulae and chemical reactions is expected. **You may use the outline included at the end of this document on how to build your essay to address each category.**

1. (Existing knowledge, research, and views) Describe the properties of the sand and sodium chloride that were used in the separation process.
2. (Analysis) Classify the mixtures created at each step in the process of separating the sand, and salt mixture as homogeneous or heterogeneous.
3. (Acquiring competencies) Describe the folding of the filter paper. Provide at least one argument why the folded filter paper would work better than the unfolded one.
4. (Acquiring competencies) Describe the main steps in a filtration.
5. (Acquiring competencies) Provide at least one argument for washing the solids during filtration.
6. (Assumptions) Predict the expected % recovery for your sand and salt. Provide a supported argument for your choice. Provide at least one assumption that must be true to explain the discrepancy between the original and recovered masses.
7. (Assumptions) Compare the % recovery from your experiment with the expected % recovery. Provide at least one assumption that must be true to explain the discrepancy between the two values.
8. (Existing knowledge, research, and views) Describe a large-scale application of separations that has an impact on our everyday lives.

Recommended discussion outline:

The mixtures we studied in this experiment are … and can be classified as ...

Separation techniques are dependent on the properties of and states of matter. Filtration requires …

In this experiment we assumed ....

In this experiment, we recovered …% of salt and … % of sand. The recovery values of our group are (precise or accurate?), because ...

An application of separation that I found fascinating is … and it works like this: ….

The purpose of the experiment was … By performing this experiment, I learned ...

CHAPTER OVERVIEW

6: Exp 5- Separation of Mixtures_F2F

6.1: Video Links

Lab Experiments (Write protocols and perform experiments based on these):

1. Making Salt, Sand and Iron Mixture

2. Separating the Iron

3. Separating Salt from Sand

4. Recovering Salt and Sand

Data analysis and calculations (Use these if you need help with your data and calculations)

1. Percent Composition

6.2: Experimental Protocol and Tables (Prelab)

The prelab must include Experimental Protocol, Chemical Table and Equipment Table.

The lab report requires all sections (including prelab sections) to be completed in one document.

Experimental Protocol

(Analysis) Watch the experiment videos. Take notes on the protocol. Stop the video and re-watch as necessary to acquire the details of the procedure. Write out the protocol for each part of the experiment. (It can be written in sequential steps. Complete sentences are not necessary.) This is the protocol you will follow, so be detailed.

Chemical Table

(Representation) Prepare your chemical table including the materials you will use in the experiment. Here is a general template that you may use.

Chemical Name	Chemical Formula	Molar Mass (g/mol)	Hazards	reference	PPE
Sodium Chloride	**NaCl**	**58.5**	**Skin irritation**	https://fscimage.fishersci.com/msds/21105.htm	

Equipment Table

(Analysis) Identify the equipment (type AND size) needed for the experiment and include the name and an image of each. Be sure to describe the equipment, how to use it, and why it is suitable for this use.

Equipment Name	Equipment Picture	Intended Purpose

6.3: Data and Analysis

Data Collection

(Acquiring competencies) Following your detailed protocol based on the videos, perform all the experiments. Record your observations and take pictures of your key steps in the process. Your observations and images need to be incorporated in your data section and this section should be as detailed as possible as you will use this information to complete your discussion.

Data Processing

1. (Representation) Using your collected measurements, fill out the table below.

Substance	Before separation (g)	After separation (g)	Percent recovery (after/before×100%) (%)	Cause for change in mass
Salt (NaCl)				
Sand (SiO2)				
Iron (Fe)				
Total				

2. (Manipulation) Calculate the percent composition of the mixture (% NaCl, % iron and % sand) using the original amounts of each substance. Show your stepwise calculation with the appropriate units.
3. (Manipulation) Calculate the percent composition of the mixture (% NaCl, % iron and % sand) using the recovered amounts of each substance. Show your stepwise calculation with the appropriate units.
4. (Manipulation) Using the total mass of the mixture before and after the separation, calculate the % recovery. Show your stepwise calculation with the appropriate units.
5. (Assumptions and Analysis) Fill in the following table using the observations and data from your experiments.

Assumptions made	Testing the assumption	If assumptions are wrong ...
The distilled water is pure	Evaporate it and check for residue	The density would change depending on the density of the contaminant
There is no iron in the sand		The magnet will extract sand along with the filings.
Our balance is accurate		

6.4: Discussion

Discussion

Write a minimum one-page (12 font, single spaced) discussion on the experiment conducted this week. Address **at least one question in each category** as fully as possible integrating the collected data, providing explanations for the observed trends, and evaluating whether your original assumptions about the experiment were validated by the results. **The assignment will be graded on completeness, clarity of the explanations and the meaningful integration of the collected and calculated data.** Correct grammar and appropriate format for the chemical formulae and chemical reactions is expected. **You may use the outline included at the end of this document on how to build your essay to address each category.**

1. (Existing knowledge, research, and views) Describe the properties of the iron, sand and sodium chloride that were used in the separation process.
2. (Analysis) Classify the mixtures created at each step in the process of separating the iron, sand, and salt mixture as homogeneous or heterogeneous.
3. (Acquiring competencies) Describe the folding of the filter paper. Provide at least one argument why the folded filter paper would work better than the unfolded one.
4. (Acquiring competencies) Describe the main steps in a filtration.
5. (Acquiring competencies) Provide at least one argument for washing the solids during filtration.
6. (Acquiring competencies) Describe how you used a magnet to separate the iron filings. Provide at least one argument for using the plastic bag.
7. (Assumptions) Predict the expected % recovery for your sand, salt, and iron. Provide a supported argument for your choice. Provide at least one assumption that must be true to explain the discrepancy between the original and recovered masses.
8. (Assumptions) Compare the % recovery from your experiment with the expected % recovery. Provide at least one assumption that must be true to explain the discrepancy between the two values.
9. (Analysis) Compare the % recovery values from your group. Comment on the accuracy and precision of the experiment.
10. (Existing knowledge, research, and views) Describe a large-scale application of separations that has an impact on our everyday lives.

Recommended discussion outline:

The mixtures we studied in this experiment are … and can be classified as ...

Separation techniques are dependent on the properties of and states of matter. Filtration requires …

In this experiment we assumed ....

In this experiment, we recovered …% of salt, ….. % iron and … % of sand. The recovery values of our group are (precise or accurate?), because ...

An application of separation that I found fascinating is … and it works like this: ….

The purpose of the experiment was … By performing this experiment, I learned ...

CHAPTER OVERVIEW

7: Exp 6- Extraction with Oil and Water_F2F

7.1: Video Links

Lab Experiments (Write protocols and perform experiments based on these):

1. Extracting the Polymer

2. Making Indicator Solution

3. Polymer with Water

4. Adding Salt to Soaked Polymer

5. Polymer with Indicator

6. Determining pH Using Indicator Solution

7. Determining pH Using pH Paper

Data analysis and calculations (Use these if you need help with your data and interpretations)

1. Absorbed Water

2. pH

7.2: Experimental Protocol and Tables (Prelab)

The prelab must include Experimental Protocol, Chemical Table and Equipment Table.

The lab report requires all sections (including prelab sections) to be completed in one document.

Experimental Protocol

(Analysis) Watch the experiment videos. Take notes on the protocol. Stop the video and re-watch as necessary to acquire the details of the procedure. Write out the protocol for each part of the experiment. (It can be written in sequential steps. Complete sentences are not necessary.) This is the protocol you will follow, so be detailed.

Chemical Table

(Representation) Prepare your chemical table including the materials you will use in the experiment. Here is a general template that you may use.

Chemical Name	Chemical Formula	Molar Mass (g/mol)	Hazards	reference	PPE
Sodium Chloride	**NaCl**	**58.5**	**Skin irritation**	https://fscimage.fishersci.com/msds/21105.htm	

Equipment Table

(Analysis) Identify the equipment (type AND size) needed for the experiment and include the name and an image of each. Be sure to describe the equipment, how to use it, and why it is suitable for this use.

Equipment Name	Equipment Picture	Intended Purpose

7.3: Data and Analysis

Data Collection

(Acquiring competencies) Following your detailed protocol based on the videos, perform all the experiments. Record your observations and take pictures of your key steps in the process. Your observations and images need to be incorporated in your data section and this section should be as detailed as possible as you will use this information to complete your discussion.

Data Processing

1. (Manipulation) Calculate the percent of the water absorbed relative to the mass of the polymer.
2. (Representation) Create a table for the results of your tests for each material with the purple cabbage indicator solution, the indicator-soaked polymer and using the pH paper.
3. Classify the substances you tested in your pH experiment as acidic, basic, or neutral.

Tested substance	Color of indicator solution (descriptive)	Color of indicator with polymer (descriptive)	pH from the pH paper	Acidic/Basic/Neutral

4. (Analysis) Evaluate your results by comparing the descriptive colors associated with materials that are acidic, basic, or neutral.
5. (Assumptions and Analysis) Fill in the following table using the observations and data from your experiments.

Assumptions made	Testing the assumption	If assumptions are wrong ...
All the extracted white solid from the diaper is polymer.		Difference between literature absorption data and our experiment.
The indicator is not affected by the presence of the polymer.	Compare the color of the indicator solution and the soaked polymer.	

7.4: Discussion

Discussion

Write a minimum one-page (12 font, single spaced) discussion on the experiment conducted this week. Address **at least one question in each category** as fully as possible integrating the collected data, providing explanations for the observed trends, and evaluating whether your original assumptions about the experiment were validated by the results. **The assignment will be graded on completeness, clarity of the explanations and the meaningful integration of the collected and calculated data.** Correct grammar and appropriate format for the chemical formulae and chemical reactions is expected. **You may use the outline included at the end of this document on how to build your essay to address each category.**

1. (Existing knowledge, research, and views) Define polymers and identify what kind of polymers are found in diapers.
2. (Analysis) Describe what happened when you added water to your polymer and use your observation to explain how a diaper works.
3. (Existing knowledge, research, and views) Look up the water uptake of this superabsorbent polymer in the literature. Describe how your result compares to that number.
4. (Existing knowledge, research, and views) Name at least 3 other applications for these super absorbent polymers and describe how they are used. Describe what makes these applications interesting to you.
5. (Analysis) Describe what happened when you added salt to your polymer. Identify at least one other substance that you expect to produce the same effect and provide an argument for the similar results.
6. (Existing knowledge, research, and views) Define pH and describe what it is used for.
7. (Existing knowledge, research, and views) Describe the pH indicator used in this experiment and how it was prepared. If the indicator wasn't the whole red cabbage, identify the specific compound.
8. (Analysis) Predict the color of the indicator and the pH of the solution if a strong acid like HCl is used in place of the vinegar. Provide an explanation for your choice.
9. (Analysis) Predict the color of the indicator and the pH of the solution if a strong base like NaOH is used instead of sodium bicarbonate. Provide an explanation for your choice.
10. (Analysis) Predict the color of the indicator and the pH of the solution if a higher concentration of the acetic acid was used instead of the 5% vinegar. Provide an explanation for your choice.
11. (Analysis) Identify the method that is most sensitive among the 3 different methods you tested in this experiment and provide a supported argument for your choice.
12. (Experimental design) Describe a practical application that requires you to determine the pH and provide a convincing argument why the red-cabbage indicator may or may not work for that purpose.

CHAPTER OVERVIEW

8: Exp 6- Extraction with Oil and Water - online

8.1: Video Links

Lab Experiments (Write protocols and perform experiments based on these):

1. Extraction with Oil and Water

Data analysis and calculations (Use these if you need help with your data and calculations)

1. Representation of Organic Molecules

2. Polarity of Bonds

3. Polarity of Molecules

4. Intermolecular Forces

8.2: Experimental Protocol and Tables (Prelab)

The prelab must include Experimental Protocol, Chemical Table and Equipment Table.

The lab report requires all sections (including prelab sections) to be completed in one document.

Experimental Protocol (Prelab)

(Analysis) Watch the experiment videos. Take notes on the protocol. Stop the video and re-watch as necessary to acquire the details of the procedure. Write out the protocol for each part of the experiment. (It can be written in sequential steps. Complete sentences are not necessary.) This is the protocol you will follow, so be detailed.

Chemical Table (Prelab)

(Representation) Prepare your chemical table including the materials you will use in the experiment. Here is a general template that you may use.

Chemical Name	Chemical Formula	Molar Mass (g/mol)	Hazards	reference	PPE
Sodium Chloride	**NaCl**	**58.5**	**Skin irritation**	https://fscimage.fishersci.com/msds/21105.htm	

Equipment Table (Prelab)

(Analysis) Identify the equipment (type AND size) needed for the experiment and include the name and an image of each. Be sure to describe the equipment, how to use it, and why it is suitable for this use.

Equipment Name	Equipment Picture	Intended Purpose

8.3: Data and Analysis

Data Collection (Data and Analysis)

(Acquiring competencies) Following your detailed protocol based on the videos, perform all the experiments. Record your observations and take pictures of your key steps in the process. Your observations and images need to be incorporated in your data section and this section should be as detailed as possible as you will use this information to complete your discussion.

Data Processing (Data and Analysis)

1. (Experiment design) Propose an alternate method for extracting the scented compounds from the plants.
2. (Assumptions and Analysis) Fill in the following table using the observations and data from your experiments.

Assumptions made	Testing the assumption	If assumptions are wrong ...
Your nose is equally sensitive to both oil and water-soluble compounds.	This would require instrumentation.	Leads to incorrect conclusions.

8.4: Discussion

Discussion

Write a minimum one-page (12 font, single spaced) discussion on the experiment conducted this week. Address **at least one question in each category** as fully as possible integrating the collected data, providing explanations for the observed trends, and evaluating whether your original assumptions about the experiment were validated by the results. **The assignment will be graded on completeness, clarity of the explanations and the meaningful integration of the collected and calculated data.** Correct grammar and appropriate format for the chemical formulae and chemical reactions is expected.

1. (Existing knowledge, research, and views) Define intermolecular forces and describe what they represent.
2. (Experiment design) Propose a practical laboratory method for determining the polarity of a molecule. Describe the protocol and the required materials.
3. (Analysis) Describe how you would determine if some of the herb/flower interacted with the oil or water fraction. Provide observations from your experiment that support your method.
4. (Analysis) Describe the odor of your water and oil fraction. Describe the similarities and differences between them and provide an explanation for them.
5. (Analysis) Describe what happened when you placed the whole herb/flower in the water and oil fractions. Compare the observations to those from the chopped/ crushed herbs.
6. (Analysis) Propose a method for determining the polarity of a molecule using the structure of the molecule. Include the structure of the compound to support your reasoning.
7. (Existing knowledge, research, and views) Look up the structure of the compound that is responsible for the scent of your herb. Describe how the structure of the compound affects the odor of the water and oil fractions.
8. (Experiment design) Propose at least one method to successfully separate oil and water.
9. (Experiment design) Propose at least one delicious combination for infused water and one for infused oil.
10. (Assumptions) Describe at least one assumption that is made when a compound is classified as water-soluble.
11. (Assumptions) Describe at least one assumption that is made when a compound is classified as soluble in oil.
12. (Analysis) Describe when, if ever a compound can be soluble in both water and oil. Provide a supported argument for your choice.

CHAPTER OVERVIEW

9: Exp 7- Polymer and pH Indicator_F2F

9.1: Video Links

Lab Experiments (Write protocols and perform experiments based on these):

1. Extracting the Polymer

2. Making Indicator Solution

3. Polymer with Water

4. Adding Salt to Soaked Polymer

5. Polymer with Indicator

6. Determining pH Using Indicator Solution

7. Determining pH Using pH Paper

Data analysis and calculations (Use these if you need help with your data and interpretations)

1. Absorbed Water

2. pH

9.2: Experimental Protocol and Tables (Prelab)

The prelab must include Experimental Protocol, Chemical Table and Equipment Table.

The lab report requires all sections (including prelab sections) to be completed in one document.

Experimental Protocol

(Analysis) Watch the experiment videos. Take notes on the protocol. Stop the video and re-watch as necessary to acquire the details of the procedure. Write out the protocol for each part of the experiment. (It can be written in sequential steps. Complete sentences are not necessary.) This is the protocol you will follow, so be detailed.

Chemical Table

(Representation) Prepare your chemical table including the materials you will use in the experiment. Here is a general template that you may use.

Chemical Name	Chemical Formula	Molar Mass (g/mol)	Hazards	reference	PPE
Sodium Chloride	**NaCl**	**58.5**	**Skin irritation**	https://fscimage.fishersci.com/msds/21105.htm	

Equipment Table

(Analysis) Identify the equipment (type AND size) needed for the experiment and include the name and an image of each. Be sure to describe the equipment, how to use it, and why it is suitable for this use.

Equipment Name	Equipment Picture	Intended Purpose

9.3: Data and Analysis

Data Collection

(Acquiring competencies) Following your detailed protocol based on the videos, perform all the experiments. Record your observations and take pictures of your key steps in the process. Your observations and images need to be incorporated in your data section and this section should be as detailed as possible as you will use this information to complete your discussion.

Data Processing

1. (Manipulation) Calculate the percent of the water absorbed relative to the mass of the polymer.
2. (Representation) Create a table for the results of your tests for each material with the purple cabbage indicator solution, the indicator-soaked polymer and using the pH paper.
3. Classify the substances you tested in your pH experiment as acidic, basic, or neutral.

Tested substance	Color of indicator solution (descriptive)	Color of indicator with polymer (descriptive)	pH from the pH paper	Acidic/Basic/Neutral

4. (Analysis) Evaluate your results by comparing the descriptive colors associated with materials that are acidic, basic, or neutral.
5. (Assumptions and Analysis) Fill in the following table using the observations and data from your experiments.

Assumptions made	Testing the assumption	If assumptions are wrong ...
All the extracted white solid from the diaper is polymer.		Difference between literature absorption data and our experiment.
The indicator is not affected by the presence of the polymer.	Compare the color of the indicator solution and the soaked polymer.	

9.4: Discussion

Discussion

Write a minimum one-page (12 font, single spaced) discussion on the experiment conducted this week. Address **at least one question in each category** as fully as possible integrating the collected data, providing explanations for the observed trends, and evaluating whether your original assumptions about the experiment were validated by the results. **The assignment will be graded on completeness, clarity of the explanations and the meaningful integration of the collected and calculated data.** Correct grammar and appropriate format for the chemical formulae and chemical reactions is expected. **You may use the outline included at the end of this document on how to build your essay to address each category.**

1. (Existing knowledge, research, and views) Define polymers and identify what kind of polymers are found in diapers.
2. (Analysis) Describe what happened when you added water to your polymer and use your observation to explain how a diaper works.
3. (Existing knowledge, research, and views) Look up the water uptake of this superabsorbent polymer in the literature. Describe how your result compares to that number.
4. (Existing knowledge, research, and views) Name at least 3 other applications for these super absorbent polymers and describe how they are used. Describe what makes these applications interesting to you.
5. (Analysis) Describe what happened when you added salt to your polymer. Identify at least one other substance that you expect to produce the same effect and provide an argument for the similar results.
6. (Existing knowledge, research, and views) Define pH and describe what it is used for.
7. (Existing knowledge, research, and views) Describe the pH indicator used in this experiment and how it was prepared. If the indicator wasn't the whole red cabbage, identify the specific compound.
8. (Analysis) Predict the color of the indicator and the pH of the solution if a strong acid like HCl is used in place of the vinegar. Provide an explanation for your choice.
9. (Analysis) Predict the color of the indicator and the pH of the solution if a strong base like NaOH is used instead of sodium bicarbonate. Provide an explanation for your choice.
10. (Analysis) Predict the color of the indicator and the pH of the solution if a higher concentration of the acetic acid was used instead of the 5% vinegar. Provide an explanation for your choice.
11. (Analysis) Identify the method that is most sensitive among the 3 different methods you tested in this experiment and provide a supported argument for your choice.
12. (Experimental design) Describe a practical application that requires you to determine the pH and provide a convincing argument why the red-cabbage indicator may or may not work for that purpose.

CHAPTER OVERVIEW

10: Exp 8- Decomposition

10.1: Video Links

Lab Experiments (Write protocols and perform experiments based on these):

1. Decomposition of Baking Soda

Data analysis and calculations (Use these if you need help with your data and interpretations)

1. Stoichiometry

2. Percent yield

3. Interpreting Chemical Equations

10.2: Experimental Protocol and Tables (Prelab)

Experimental Protocol

(Analysis) Watch the experiment videos. Take notes on the protocol. Stop the video and re-watch as necessary to acquire the details of the procedure. Write out the protocol for each part of the experiment. (It can be written in sequential steps. Complete sentences are not necessary.) This is the protocol you will follow, so be detailed.

Chemical Table

(Representation) Prepare your chemical table including the materials you will use in the experiment. Here is a general template that you may use.

Chemical Name	Chemical Formula	Molar Mass (g/mol)	Hazards	reference	PPE
Sodium Chloride	**NaCl**	**58.5**	**Skin irritation**	**https://fscimage.fishersci.com/msds/21105.htm**	

Equipment Table

(Analysis) Identify the equipment (type AND size) needed for the experiment and include the name and an image of each. Be sure to describe the equipment, how to use it, and why it is suitable for this use.

Equipment Name	Equipment Picture	Intended Purpose

10.3: Data and Analysis

Data Collection

(Acquiring competencies) Following your detailed protocol based on the videos, perform all the experiments. Record your observations and take pictures of your key steps in the process. Your observations and images need to be incorporated in your data section and this section should be as detailed as possible as you will use this information to complete your discussion.

Data Processing

1. (Manipulation) Calculate the percent yield of the reaction. Show your calculations with the appropriate units.
2. (Manipulation) Collect the percent yield values from your group members and calculate the average percent yield for your group.
3. (Assumptions and Analysis) Fill in the following table using the observations and data from your experiments.

Assumptions made	Testing the assumption	If assumptions are wrong ...
Only CO_2 and H_2O are released in the reaction.	Funnel the gases in indicator solution.	
The sodium carbonate does not change back to sodium bicarbonate even if there is water and CO2 available.		

10.4: Discussion

Discussion

Write a minimum one-page (12 font, single spaced) discussion on the experiment conducted this week. Address **at least one question in each category** as fully as possible integrating the collected data, providing explanations for the observed trends, and evaluating whether your original assumptions about the experiment were validated by the results. **The assignment will be graded on completeness, clarity of the explanations and the meaningful integration of the collected and calculated data.** Correct grammar and appropriate format for the chemical formulae and chemical reactions is expected. **You may use the outline included at the end of this document on how to build your essay to address each category.**

1. (Representation) Write a balanced chemical equation for the performed reaction indicating the states of all involved chemicals.
2. (Interpretation) Using your balanced chemical equation that describes the observed reaction, interpret its meaning on the microscopic and macroscopic scale.
3. (Existing knowledge, research, and views) Classify the chemical reaction and provide evidence to support your choice(s).
4. (Manipulation) Describe how percent yield is calculated and use your calculations to demonstrate the steps involved.
5. (Assumptions and Limitations) Describe at least one assumption you make when calculating the theoretical yield. Identify at least two reasons from your experiment that make it impossible for the actual yield and theoretical yield to be identical.
6. (Acquiring competencies) Describe how you made your solution and comment on its concentration.
7. (Experimental design) Propose a method for testing your sodium carbonate at the end of the experiment to confirm that it didn't react with the water and the CO2 from the air.

CHAPTER OVERVIEW

11: Exp 8- Decomposition - online

11.1: Video Links

Lab Experiments (Write protocols and perform experiments based on these):

1. Decomposition of Baking Soda (version 1)

2. Decomposition of Baking Soda (version 2)

Data analysis and calculations (Use these if you need help with your data and calculations)

1. Simple Stoichiometry

2. Percent Yield

3. Interpreting Chemical Equations

11.2: Experimental Protocol and Tables (Prelab)

The prelab must include Experimental Protocol, Chemical Table and Equipment Table.

The lab report requires all sections (including prelab sections) to be completed in one document.

Experimental Protocol

(Analysis) Watch the experiment videos. Take notes on the protocol. Stop the video and re-watch as necessary to acquire the details of the procedure. Write out the protocol for each part of the experiment. (It can be written in sequential steps. Complete sentences are not necessary.) This is the protocol you will follow, so be detailed.

Chemical Table

(Representation) Prepare your chemical table including the materials you will use in the experiment. Here is a general template that you may use.

Chemical Name	Chemical Formula	Molar Mass (g/mol)	Hazards	reference	PPE
Sodium Chloride	**NaCl**	**58.5**	**Skin irritation**	https://fscimage.fishersci.com/msds/21105.htm	

Equipment Table

(Analysis) Identify the equipment (type AND size) needed for the experiment and include the name and an image of each. Be sure to describe the equipment, how to use it, and why it is suitable for this use.

Equipment Name	Equipment Picture	Intended Purpose

11.3: Data and Analysis

Data Collection

(Acquiring competencies) Following your detailed protocol based on the videos, perform all the experiments. Record your observations and take pictures of your key steps in the process. Your observations and images need to be incorporated in your data section and this section should be as detailed as possible as you will use this information to complete your discussion.

Data Processing

1. (Manipulation) Calculate the percent yield of the reaction. Show your calculations with the appropriate units.
2. (Manipulation) Collect the percent yield values from your group members and calculate the average percent yield for your group.
3. (Assumptions and Analysis) Fill in the following table using the observations and data from your experiments.

Assumptions made	Testing the assumption	If assumptions are wrong ...
Only CO_2 and H_2O are released in the reaction.	Funnel the gases in indicator solution.	
The sodium carbonate does not change back to sodium bicarbonate even if there is water and CO_2 available.		

11.4: Discussion

Discussion

Write a minimum one-page (12 font, single spaced) discussion on the experiment conducted this week. Address **at least one question in each category** as fully as possible integrating the collected data, providing explanations for the observed trends, and evaluating whether your original assumptions about the experiment were validated by the results. **The assignment will be graded on completeness, clarity of the explanations and the meaningful integration of the collected and calculated data.** Correct grammar and appropriate format for the chemical formulae and chemical reactions is expected.

1. (Representation) Write a balanced chemical equation for the performed reaction indicating the states of all involved chemicals.
2. (Interpretation) Using your balanced chemical equation that describes the observed reaction, interpret its meaning on the microscopic and macroscopic scale.
3. (Existing knowledge, research, and views) Classify the chemical reaction and provide evidence to support your choice(s).
4. (Manipulation) Describe how percent yield is calculated and use your calculations to demonstrate the steps involved.
5. (Assumptions and Limitations) Describe at least one assumption you make when calculating the theoretical yield. Identify at least two reasons from your experiment that make it impossible for the actual yield and theoretical yield to be identical.
6. (Analysis) Compare the methods used by your group and identify which method resulted in the best percent yield. Describe any steps that the person who got that yield did differently.
7. (Analysis) Describe the purpose for having the thread hang loosely between the cups.
8. (Experimental design) Propose a method for testing your sodium carbonate at the end of the experiment to confirm that it didn't react with the water and the CO2 from the air.

CHAPTER OVERVIEW

12: Exp 9- Gravimetric Analysis

12.1: Video Links

Lab Experiments (Write protocols and perform experiments based on these):

1. Extracting the Calcium from Eggshells

2. Extracting the Calcium from Eggshells - Continued

3. Making the Saturated Na2CO3 Solution

4. Precipitating the Calcium from Calcium Acetate

Data analysis and calculations (Use these if you need help with your data and calculations)

1. Extraction of Calcium from Eggshells

2. Determining the Amount of Calcium

3. Interpreting Chemical Equations

12.2: Experimental Protocol and Tables (Prelab)

The prelab must include Experimental Protocol, Chemical Table and Equipment Table.

The lab report requires all sections (including prelab sections) to be completed in one document.

Experimental Protocol

(Analysis) Watch the experiment videos. Take notes on the protocol. Stop the video and re-watch as necessary to acquire the details of the procedure. Write out the protocol for each part of the experiment. (It can be written in sequential steps. Complete sentences are not necessary.) This is the protocol you will follow, so be detailed.

Chemical Table

(Representation) Prepare your chemical table including the materials you will use in the experiment. Here is a general template that you may use.

Chemical Name	Chemical Formula	Molar Mass (g/mol)	Hazards	reference	PPE
Sodium Chloride	**NaCl**	**58.5**	**Skin irritation**	https://fscimage.fishersci.com/msds/21105.htm	

Equipment Table

(Analysis) Identify the equipment (type AND size) needed for the experiment and include the name and an image of each. Be sure to describe the equipment, how to use it, and why it is suitable for this use.

Equipment Name	Equipment Picture	Intended Purpose

12.3: Data and Analysis

Data Collection

(Acquiring competencies) Following your detailed protocol based on the videos, perform all the experiments. Record your observations and take pictures of your key steps in the process. Your observations and images need to be incorporated in your data section and this section should be as detailed as possible as you will use this information to complete your discussion.

Data Processing

1. (Existing knowledge, research, and views) Identify the main ingredient in eggshells.
2. (Representation) Write the balanced chemical equation for the observed reaction between the eggshell and the vinegar.
3. (Representation) Write the balanced chemical equation for the reaction that produced the calcium carbonate precipitate.
4. (Manipulation) Using the mass of the calcium carbonate precipitate, calculate the mass of the calcium ions in the eggshell. (Hint: You will need to use both balanced chemical equations.) Show all your work with the appropriate units.
5. (Manipulation) Calculate the percent calcium in the eggshell. (Hint: you can only do this for the broken eggshells that you weighed before the experiment.)
6. (Assumptions and Analysis) Fill in the following table using the observations and data from your experiments.

Assumptions made	Testing the assumption	If assumptions are wrong ...
There is no calcium in vinegar.		

12.4: Discussion

Discussion

Write a minimum one-page (12 font, single spaced) discussion on the experiment conducted this week. Address **at least one question in each category** as fully as possible integrating the collected data, providing explanations for the observed trends, and evaluating whether your original assumptions about the experiment were validated by the results. **The assignment will be graded on completeness, clarity of the explanations and the meaningful integration of the collected and calculated data.** Correct grammar and appropriate format for the chemical formulae and chemical reactions is expected.

1. (Existing knowledge, research, and views) Describe the components of an egg and indicate the main ingredient in each component.
2. (Interpretation) Using your balanced chemical equations that describes the observed reactions, interpret their meaning on the microscopic and macroscopic scale.
3. (Representation) Starting with the molecular equations, derive the total ionic and net ionic equations for each balanced chemical equation.
4. (Interpretation) Using your balanced chemical equations and your observations, identify the limiting reactant and excess reactant in each reaction.
5. (Experiment design) Provide an argument for letting the egg sit in the vinegar for 24 hours before replacing the vinegar. Suggest at least one method that would speed up the reaction.
6. (Experiment design) Provide an argument for removing the solution and adding fresh vinegar to the egg after 24 hours. Describe why this step was necessary and suggest an alternative to it.
7. (Experiment design) Provide a supported argument for using the sodium carbonate solution to precipitate the calcium and not sodium carbonate powder. (Hint: consider the definition of a precipitation reaction for this answer.)
8. (Analysis) If you didn't have sodium carbonate available, what other compounds could you have used to precipitate the calcium ions? (Hint: consider the solubility table.)
9. (Analysis) Describe the difference between the reaction of the whole egg and the cracked eggshells with vinegar. Provide at least one supported argument for the difference in the reactions.
10. (Analysis) Compare your grams of calcium carbonate collected from your individual eggshells. Provide at least one argument for the similarity and one argument for the observed differences.
11. (Assumptions and Limitations) Describe at least one assumption you make when calculating the amount of calcium from your eggshell. Identify at least two reasons from your experiment that make it impossible to determine the exact amount of calcium in the eggshell.
12. (Analysis) Compare the percent calcium of your eggshells with your group. Provide at least one argument that explains the similarity and one for the difference.
13. (Existing knowledge, research, and views) Birds are not the only species that lay eggs. Identify the main ingredient in those eggs and evaluate whether you could perform this experiment on those.
14. (Existing knowledge, research, and views) Calcium carbonate is a white powder, and yet the eggshells can have a variety of colors. Identify at least one cause for the variation in colors.
15. (Existing knowledge, research, and views) Calcium carbonate is commonly found in nature. List at least 3 materials, beyond eggshells that are made of calcium carbonate. Comment on the difference in their properties despite their similar composition.

CHAPTER OVERVIEW

13: Exp 9- Gravimetric Analysis_F2F

13.1: Video Links

Lab Experiments (Write protocols and perform experiments based on these):

1. Making a 1 M HCl Solution

2. Extracting the Calcium from Chalk

3. Making the Saturated Na_2CO_3 Solution

4. Precipitating the Calcium from Calcium Chloride

Data analysis and calculations (Use these if you need help with your data and interpretations)

1. Extraction of Calcium from Chalk

2. Determining the Amount of Calcium

3. Interpreting Chemical Equations

13.2: Experimental Protocol and Tables (Prelab)

The prelab must include Experimental Protocol, Chemical Table and Equipment Table.

The lab report requires all sections (including prelab sections) to be completed in one document.

Experimental Protocol

(Analysis) Watch the experiment videos. Take notes on the protocol. Stop the video and re-watch as necessary to acquire the details of the procedure. Write out the protocol for each part of the experiment. (It can be written in sequential steps. Complete sentences are not necessary.) This is the protocol you will follow, so be detailed.

Chemical Table

(Representation) Prepare your chemical table including the materials you will use in the experiment. Here is a general template that you may use.

Chemical Name	Chemical Formula	Molar Mass (g/mol)	Hazards	reference	PPE
Sodium Chloride	**NaCl**	**58.5**	**Skin irritation**	https://fscimage.fishersci.com/msds/21105.htm	

Equipment Table

(Analysis) Identify the equipment (type AND size) needed for the experiment and include the name and an image of each. Be sure to describe the equipment, how to use it, and why it is suitable for this use.

Equipment Name	Equipment Picture	Intended Purpose

13.3: Data and Analysis

Data Collection

(Acquiring competencies) Following your detailed protocol based on the videos, perform all the experiments. Record your observations and take pictures of your key steps in the process. Your observations and images need to be incorporated in your data section and this section should be as detailed as possible as you will use this information to complete your discussion.

Data Processing

1. (Existing knowledge, research, and views) Identify the main ingredient in chalk.
2. (Representation) Write the balanced chemical equation for the observed reaction between the chalk and the hydrochloric acid.
3. (Representation) Write the balanced chemical equation for the reaction that produced the calcium carbonate precipitate.
4. (Manipulation) Using the mass of the calcium carbonate precipitate, calculate the mass of the calcium ions in the crushed chalk. (Hint: You will need to use both balanced chemical equations.) Show all your work with the appropriate units.
5. (Manipulation) Using the mass of the calcium carbonate precipitate, calculate the mass of the calcium ions in the powdered chalk. (Hint: You will need to use both balanced chemical equations.) Show all your work with the appropriate units.
6. (Manipulation) Calculate the percent calcium in chalk.
7. (Assumptions and Analysis) Fill in the following table using the observations and data from your experiments.

Assumptions made	Testing the assumption	If assumptions are wrong ...
There is no calcium in hydrochloric acid.		

13.4: Discussion

Discussion

Write a minimum one-page (12 font, single spaced) discussion on the experiment conducted this week. Address **at least one question in each category** as fully as possible integrating the collected data, providing explanations for the observed trends, and evaluating whether your original assumptions about the experiment were validated by the results. **The assignment will be graded on completeness, clarity of the explanations and the meaningful integration of the collected and calculated data.** Correct grammar and appropriate format for the chemical formulae and chemical reactions is expected. **You may use the outline included at the end of this document on how to build your essay to address each category.**

1. (Existing knowledge, research, and views) Identify the main ingredient in chalk.
2. (Interpretation) Using your balanced chemical equations that describe the observed reactions, interpret their meaning of each equation on the microscopic and macroscopic scale.
3. (Representation) Starting with the molecular equations, derive the total ionic and net ionic equations for each balanced chemical equation.
4. (Interpretation) Using your balanced chemical equations and your observations, identify the limiting reactant and excess reactant in each reaction.
5. (Experiment design) Provide a supported argument for using the sodium carbonate solution to precipitate the calcium and not sodium carbonate powder. (Hint: consider the definition of a precipitation reaction for this answer.)
6. (Analysis) If you didn't have sodium carbonate available, what other compounds could you have used to precipitate the calcium ions? (Hint: consider the solubility table.)
7. (Assumptions and Limitations) Describe at least one assumption you make when calculating the amount of calcium from your chalk. Identify at least two reasons from your experiment that make it impossible to determine the exact amount of calcium in the chalk.
8. (Analysis) Compare the percent calcium of your chalks with the other groups in the class. Provide at least one argument that explains the similarity and one for the difference.
9. (Existing knowledge, research, and views) Calcium carbonate is a white powder, and yet the chalks can have a variety of colors. Describe how colored chalks are made.
10. (Existing knowledge, research, and views) Describe the difference between pigments and dyes.
11. (Analysis) Predict if adding food coloring to calcium carbonate would result in colored chalk. Provide a supported argument for your choice.
12. (Existing knowledge, research, and views) Calcium carbonate is commonly found in nature. List at least 3 materials, beyond chalk that are made of calcium carbonate. Comment on the difference in their properties despite their similar composition.

CHAPTER OVERVIEW

14: Exp 10- Limiting Reactants

14.1: Video Links

Lab Experiments (Write protocols and perform experiments based on these):

1. Limiting Reactant – Part 1

2. Limiting Reactant – Part 2

3. Limiting Reactant – Part 3

Data analysis and calculations (Use these if you need help with your data and interpretations)

1. Interpreting Chemical Equations

2. Reaction of Alka-Seltzer and Water

3. Reaction of Alka-Seltzer and Vinegar

14.2: Experimental Protocol and Tables (Prelab)

The prelab must include Experimental Protocol, Chemical Table and Equipment Table.

The lab report requires all sections (including prelab sections) to be completed in one document.

Experimental Protocol

(Analysis) Watch the experiment videos. Take notes on the protocol. Stop the video and re-watch as necessary to acquire the details of the procedure. Write out the protocol for each part of the experiment. (It can be written in sequential steps. Complete sentences are not necessary.) This is the protocol you will follow, so be detailed.

Chemical Table

(Representation) Prepare your chemical table including the materials you will use in the experiment. Here is a general template that you may use.

Chemical Name	Chemical Formula	Molar Mass (g/mol)	Hazards	reference	PPE
Sodium Chloride	**NaCl**	**58.5**	**Skin irritation**	https://fscimage.fishersci.com/msds/21105.htm	

Equipment Table

(Analysis) Identify the equipment (type AND size) needed for the experiment and include the name and an image of each. Be sure to describe the equipment, how to use it, and why it is suitable for this use.

Equipment Name	Equipment Picture	Intended Purpose

14.3: Data and Analysis

Data Collection

1. (Acquiring competencies) Following your detailed protocol based on the videos, perform all the experiments. Record your observations and take pictures of your key steps in the process. Your observations and images need to be incorporated in your data section and this section should be as detailed as possible as you will use this information to complete your discussion.
2. (Representation) Make sure to collect all the data that is required to fill out this table as you work your way through the experiment. The volumes are suggested amounts, update those with your measured values.

Experiment number	Mass of tablet (g)	Mass of cup (g)	Volume of vinegar (mL)	Volume of water (mL)	Mass of cup with water and vinegar (g)	Mass of cup with water and vinegar + mass of tablet (g)	Mass of cup after experiment (g)	Mass lost during the experiment (g)
1			0	35				
2			5	30				
3			10	25				
4			15	20				
5			20	15				
6			25	10				
7			30	5				
8			35	0				

Data Processing

1. (Existing knowledge, research, and views) List the ingredients contained in Alka-Seltzer and their amounts.
2. (Representation) Write the chemical equation for the reaction that occurs when Alka-Seltzer dissolves in water.
3. (Representation) Write the chemical equations for the reactions that occurs when Alka-Seltzer reacts with vinegar.
4. (Manipulation) The mass lost during the experiment is the carbon dioxide gas that bubbled out of your solution. Using the mass of the carbon dioxide from the experiments and the chemical equations from questions 2 and 3, calculate the mass of the sodium bicarbonate in each tablet. (Hint: There will be 8 calculations.) Write each calculation with the appropriate units.
5. (Manipulation) Using the previously calculated masses of sodium bicarbonate and the measured mass of each tablet, calculate the consumed sodium bicarbonate percentage of each tablet. (Hint: There will be 8 calculations.) Write each calculation with the appropriate units.
6. (Representation) Organize your calculated values in the following table and plot the volume of vinegar on the x axis and the percent for the consumed mass of the tablet on the y axis.

Experiment number	Volume of vinegar (mL)	Mass of generated CO_2 (g)	Mass of consumed $NaHCO_3$ (g)	Consumed $NaHCO_3$ percentage of tablet (%)
1	0			
2	5			
3	10			

Experiment number	Volume of vinegar (mL)	Mass of generated CO2 (g)	Mass of consumed NaHCO3 (g)	Consumed NaHCO3 percentage of tablet (%)
4	15			
5	20			
6	25			
7	30			
8	35			

7. (Assumptions and Analysis) Fill in the following table using the observations and data from your experiments.

Assumptions made	Testing the assumption	If assumptions are wrong ...
There is sufficient water to dissolve all the sodium bicarbonate.	Dissolve the same tablet in a larger volume of water and compare the residue.	
The citric acid is the limiting reactant in the Alka-Seltzer tablet.		

14.4: Discussion

Discussion

Write a minimum one-page (12 font, single spaced) discussion on the experiment conducted this week. Address **at least one question in each category** as fully as possible integrating the collected data, providing explanations for the observed trends, and evaluating whether your original assumptions about the experiment were validated by the results. **The assignment will be graded on completeness, clarity of the explanations and the meaningful integration of the collected and calculated data.** Correct grammar and appropriate format for the chemical formulae and chemical reactions is expected. **You may use the outline included at the end of this document on how to build your essay to address each category.**

1. (Analysis) Describe what happens when vinegar is added to water.
2. (Interpretation) Using your balanced chemical equation that describes the observed reaction of the Alka-Seltzer in water, interpret its meaning on the microscopic and macroscopic scale.
3. (Analysis) Bubbles of CO_2 formed during your reactions. Provide at least one argument for why the CO_2 molecules didn't remain in the solution.
4. (Analysis) Provide and argument in favor of using a scale that reads to the hundredths place for this experiment.
5. (Analysis) Provide a valid reason for waiting until there are no more bubbles produced or present in the solution before recording the final mass of the reaction.
6. (Analysis) Identify which measured and calculated values would change if you stopped the experiment early. Predict if the values would increase or decrease as a result of rushing the experiment.
7. (Interpretation) Using your balanced chemical equation that describes the observed reaction of the Alka-Seltzer with vinegar, interpret its meaning on the microscopic and macroscopic scale.
8. (Analysis) If Alka-Seltzer undergoes a reaction even when dissolved in water, provide a supported argument for using vinegar.
9. (Assumptions) The difference in mass between the starting materials and the reactants is the gaseous carbon dioxide that was produced. Describe at least one assumption that would make this statement valid.
10. (Interpretation) Describe your graph. Identify at what volume of vinegar added did the sodium bicarbonate become the limiting reactant.
11. (Assumptions and limitations) The mass of CO_2 lost between the different cups changes because the amount of vinegar used increased between additions. Describe at least one assumption regarding the limiting reactants that would make this statement valid and one that makes it invalid. Use your graph to support your arguments.
12. (Analysis) Identify the limiting reactant when only water or a small amount of vinegar was used. Provide numerical evidence to support your argument.
13. (Analysis) Identify the limiting reactant when a large amount of vinegar was used. Provide numerical evidence to support your argument.
14. (Analysis) Compare your % $NaHCO_3$ in an Alka-Seltzer tablet with the manufacturer's data. Comment on the accuracy and precision of the experiment.

CHAPTER OVERVIEW

15: Exp 11- Gas Laws_F2F

15.1: Video Links

Lab Experiments (Write protocols and perform experiments based on these):

1. Collecting CO2 over Water

2. Collecting H2 over Water

Data analysis and calculations (Use these if you need help with your data and interpretations)

1. Stoichiometry

2. Ideal Gas Law

3. Dalton’s Law

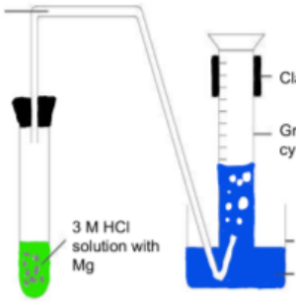
4. Volume of a Sphere

5. Interpreting Chemical Equations

15.2: Experimental Protocol and Tables (Prelab)

The prelab must include Experimental Protocol, Chemical Table and Equipment Table.

The lab report requires all sections (including prelab sections) to be completed in one document.



Experimental Protocol

(Analysis) Watch the experiment videos. Take notes on the protocol. Stop the video and re-watch as necessary to acquire the details of the procedure. Write out the protocol for each part of the experiment. (It can be written in sequential steps. Complete sentences are not necessary.) This is the protocol you will follow, so be detailed.

Chemical Table

(Representation) Prepare your chemical table including the materials you will use in the experiment. Here is a general template that you may use.

Chemical Name	Chemical Formula	Molar Mass (g/mol)	Hazards	reference	PPE
Sodium Chloride	**NaCl**	**58.5**	**Skin irritation**	https://fscimage.fishersci.com/msds/21105.htm	

Equipment Table

(Analysis) Identify the equipment (type AND size) needed for the experiment and include the name and an image of each. Be sure to describe the equipment, how to use it, and why it is suitable for this use.

Equipment Name	Equipment Picture	Intended Purpose

Equipment Name	Equipment Picture	Intended Purpose

15.3: Data and Analysis

Data Collection

(Acquiring competencies) Following your detailed protocol based on the videos, perform all the experiments. Record your observations and take pictures of your key steps in the process. Your observations and images need to be incorporated in your data section and this section should be as detailed as possible as you will use this information to complete your discussion.

Data Processing

1. (Representation) Write the balanced chemical equation for the reaction observed in the first part of this experiment.
2. (Interpretation) Using your balanced chemical equation that describes the observed reaction, interpret its meaning on the microscopic (molecules/formula units) and macroscopic scale (moles).
3. (Manipulation) Assuming that all the baking soda from your balloon reacted, calculate how many moles of carbon dioxide gas would be formed.
4. (Manipulation) Assuming that all the acetic acid (assume 5% by mass with a density of 1.006 g/ml) from your Erlenmeyer flask reacted, calculate how many moles of carbon dioxide gas would be formed.
5. (Analysis) Using your calculations, identify the limiting reactant of your reaction and determine the maximum amount (in moles) of carbon dioxide that could be produced.
6. (Manipulation) Using your calculated number of moles of carbon dioxide from Question 5, the atmospheric pressure, the vapor pressure of water at your room temperature, and your room temperature value, calculate the expected volume of the balloon.
7. (Manipulation) Using your measurement for the circumference of the balloon, calculate the volume of the gas in the balloon.

Radius: $r = \dfrac{\text{circumference}}{2p}$

Volume: $V = \dfrac{4}{3} \times \mathrm{p} \times r^3$

8. (Manipulation) Using the expected and the measured volumes of the carbon dioxide, calculate the percent yield of the experiment.
9. (Manipulation) Calculate the expected volume for 1 mole of an ideal gas under atmospheric pressure and you room temperature conditions.
10. (Manipulation) Using your measured gas volume and calculated moles from Question 5, calculate the molar volume of your collected carbon dioxide gas.
11. (Manipulation) Considering the value calculated in Question 9 the correct value for the molar volume under your reaction conditions, calculate the error for the molar volume in your experiment. (Hint: the calculated value from Question 10 is your experimental molar volume.)
12. (Representation) Write the balanced chemical equation for the reaction between the magnesium strips and the hydrochloric acid solution.
13. (Interpretation) Describe the meaning of the chemical equation on the microscopic and macroscopic scale.
14. (Manipulation) Calculate the moles of hydrogen gas expected from the reaction of HCl with Mg. Use stoichiometry, appropriate units and consider the significant figures.
15. (Manipulation) Calculate the actual moles of hydrogen gas produced using the collected volume of gas. (HINT: the gas was collected over water.)
16. (Manipulation) Calculate the % yield of the reaction. $[\text{Actual moles of } \mathrm{H_2(\,g)} / \text{ expected moles of } \mathrm{H_2(\,g)}] \times 100\%$
17. (Assumptions and Analysis) Fill in the following table using the observations and data from your experiments.

Assumptions made	Testing the assumption	If assumptions are wrong ...

Assumptions made	Testing the assumption	If assumptions are wrong ...
All the baking soda is consumed in the reaction.		

15.4: Discussion

Discussion

Write a minimum one-page (12 font, single spaced) discussion on the experiment conducted this week. Address **at least one question in each category** as fully as possible integrating the collected data, providing explanations for the observed trends, and evaluating whether your original assumptions about the experiment were validated by the results. **The assignment will be graded on completeness, clarity of the explanations and the meaningful integration of the collected and calculated data.** Correct grammar and appropriate format for the chemical formulae and chemical reactions is expected. **You may use the outline included at the end of this document on how to build your essay to address each category.**

1. (Existing knowledge, research, and views) Define ideal gases in your own words and describe the conditions under which a gas will behave as an ideal gas.
2. (Analysis) Describe your experimental conditions and compare them to the conditions described in your answer to Question 1. Explain how this knowledge influences the type of equations that you can use to do your calculations.
3. (Analysis) Describe and explain the method you used to identify the limiting reactant for your experiment. Use your calculated values to support your arguments.
4. (Analysis) Compare your actual yield (volume of the balloon) with your theoretical yield (calculated gas volume) and provide at least one supported argument for the difference between them. Describe the suspected cause and evaluate whether the expected impact is consistent with your calculations. (Hint: consider the solubility of carbon dioxide in water.)
5. (Analysis) Compare the % yield values for the baking soda and vinegar experiment with the groups in the class. Comment on the accuracy and precision of the experiment.
6. (Analysis) Compare the % yield values for the magnesium and hydrochloric acid experiment with the groups in the class. Comment on the accuracy and precision of the experiment.
7. (Analysis) The molar volume should be the same for all gases when they behave as ideal gases. Consider the properties of carbon dioxide (hint: polarity and solubility in water) and use them to explain the differences between the molar volume of an ideal gas and the molar volume of your carbon dioxide.
8. (Assumptions and limitations) Identify at least one assumption that you made about CO_2 being suitable for this experiment. (Hint: consider polarity and solubility in water.) If this assumption is not valid, describe how it impacts the volume of the gas collected in the experiment.
9. (Assumptions and limitations) Identify at least one assumption that you made about H_2 being suitable for this experiment. (Hint: consider polarity and solubility in water.) If this assumption is not valid, describe how it impacts the volume of the gas collected in the experiment.
10. (Analysis) Propose at least two other gases that would be better suited for such and experiment and two gases that would be worse. Support your choices with relevant information about the proposed gases.

CHAPTER OVERVIEW

16: Exp 11- Gas Laws - online

16.1: Video Links

Lab Experiments (Write protocols and perform experiments based on these):

1. Collecting CO2 over Water

Demonstration (For entertainment):

1. Pharaoh's Serpent Demonstration

2. Ammonia Fountain Demonstration

Data analysis and calculations (Use these if you need help with your data and calculations)

1. Stoichiometry

2. Ideal Gas Law

3. Dalton's Law

4. Volume of a Sphere

5. Interpreting Chemical Equations

16.2: Experimental Protocol and Tables (Prelab)

The prelab must include Experimental Protocol, Chemical Table and Equipment Table.

The lab report requires all sections (including prelab sections) to be completed in one document.

Experimental Protocol

(Analysis) Watch the experiment videos. Take notes on the protocol. Stop the video and re-watch as necessary to acquire the details of the procedure. Write out the protocol for each part of the experiment. (It can be written in sequential steps. Complete sentences are not necessary.) This is the protocol you will follow, so be detailed.

Chemical Table

(Representation) Prepare your chemical table including the materials you will use in the experiment. Here is a general template that you may use.

Chemical Name	Chemical Formula	Molar Mass (g/mol)	Hazards	reference	PPE
Sodium Chloride	**NaCl**	**58.5**	**Skin irritation**	https://fscimage.fishersci.com/msds/21105.htm	

Equipment Table

(Analysis) Identify the equipment (type AND size) needed for the experiment and include the name and an image of each. Be sure to describe the equipment, how to use it, and why it is suitable for this use.

Equipment Name	Equipment Picture	Intended Purpose

16.3: Data and Analysis

Data Collection

(Acquiring competencies) Following your detailed protocol based on the videos, perform all the experiments. Record your observations and take pictures of your key steps in the process. Your observations and images need to be incorporated in your data section and this section should be as detailed as possible as you will use this information to complete your discussion.

Data Processing

1. (Representation) Write the balanced chemical equation for the reaction observed in the first part of this experiment.
2. (Manipulation) Assuming that all the baking soda from your balloon reacted, calculate how many moles of carbon dioxide gas would be formed.
3. (Manipulation) Assuming that all the acetic acid (assume 5% by mass with a density of 1.006 g/ml) from your Erlenmeyer flask reacted, calculate how many moles of carbon dioxide gas would be formed.
4. (Analysis) Using your calculations, identify the limiting reactant of your reaction and determine the maximum amount (in moles) of carbon dioxide that could be produced.
5. (Manipulation) Using your calculated number of moles of carbon dioxide from Question 4, the atmospheric pressure, the vapor pressure of water at your room temperature, and your room temperature value, calculate the expected volume of the balloon.
6. (Manipulation) Using your measurement for the circumference of the balloon, calculate the volume of the gas in the balloon.

Radius: $r = \dfrac{\text{circumference}}{2p}$

Volume: $V = \dfrac{4}{3} \times \text{p} \times r^3$

7. (Manipulation) Using the expected and the measured volumes of the carbon dioxide, calculate the percent yield of the experiment.
8. (Manipulation) Calculate the expected volume for 1 mole of an ideal gas under atmospheric pressure and you room temperature conditions.
9. (Manipulation) Using your measured gas volume and calculated moles from Question 4, calculate the molar volume of your collected carbon dioxide gas.
10. (Manipulation) Considering the value calculated in Question 8 the correct value for the molar volume under your reaction conditions, calculate the error for the molar volume in your experiment. (Hint: the calculated value from Question 9 is your experimental molar volume.)
11. (Assumptions and Analysis) Fill in the following table using the observations and data from your experiments.

Assumptions made	Testing the assumption	If assumptions are wrong ...
All the baking soda is consumed in the reaction.		

16.4: Discussion

Discussion

Write a minimum one-page (12 font, single spaced) discussion on the experiment conducted this week. Address **at least one question in each category** as fully as possible integrating the collected data, providing explanations for the observed trends, and evaluating whether your original assumptions about the experiment were validated by the results. **The assignment will be graded on completeness, clarity of the explanations and the meaningful integration of the collected and calculated data.** Correct grammar and appropriate format for the chemical formulae and chemical reactions is expected.

1. (Existing knowledge, research, and views) Define ideal gases in your own words and describe the conditions under which a gas will behave as an ideal gas.
2. (Analysis) Describe your experimental conditions and compare them to the conditions described in your answer to Question 1. Explain how this knowledge influences the type of equations that you can use to do your calculations.
3. (Interpretation) Using your balanced chemical equation that describes the observed reaction, interpret its meaning on the microscopic (molecules/formula units) and macroscopic scale (moles).
4. (Interpretation) Describe and explain the method you used to identify the limiting reactant for your experiment. Use your calculated values to support your arguments.
5. (Analysis) Compare your actual yield (volume of the balloon) with your theoretical yield (calculated gas volume) and provide at least one supported argument for the difference between them. Describe the suspected cause and evaluate whether the expected impact is consistent with your calculations. (Hint: consider the solubility of carbon dioxide in water.)
6. (Analysis) Compare the % yield values from your group. Comment on the accuracy and precision of the experiment.
7. (Analysis) The molar volume should be the same for all gases when they behave as ideal gases. Consider the properties of carbon dioxide (hint: polarity and solubility in water) and use them to explain the differences between the molar volume of an ideal gas and the molar volume of your carbon dioxide.
8. (Assumptions and limitations) Identify at least one assumption that you made about CO2 being suitable for this experiment. (Hint: consider polarity and solubility in water. If this assumption is not valid, describe how it impacts the volume of the gas collected in the experiment.
9. (Analysis) Propose at least two other gases that would be better suited for such and experiment and two gases that would be worse. Support your choices with relevant information about the proposed gases.

CHAPTER OVERVIEW

17: Exp 12- Thermal Equilibrium

17.1: Video Links

Lab Experiments (Write protocols and perform experiments based on these):

1. Enthalpy of Fusion of Ice

2. Specific Heat of Ice

Data analysis and calculations (Use these if you need help with your data and interpretations)

1. Calorimetry for Phase Transitions

17.2: Experimental Protocol and Tables (Prelab)

The prelab must include Experimental Protocol, Chemical Table and Equipment Table.

The lab report requires all sections (including prelab sections) to be completed in one document.

Experimental Protocol

(Analysis) Watch the experiment videos. Take notes on the protocol. Stop the video and re-watch as necessary to acquire the details of the procedure. Write out the protocol for each part of the experiment. (It can be written in sequential steps. Complete sentences are not necessary.) This is the protocol you will follow, so be detailed.

Chemical Table

(Representation) Prepare your chemical table including the materials you will use in the experiment. Here is a general template that you may use.

Chemical Name	Chemical Formula	Molar Mass (g/mol)	Hazards	reference	PPE
Sodium Chloride	**NaCl**	**58.5**	**Skin irritation**	https://fscimage.fishersci.com/msds/21105.htm	

Equipment Table

(Analysis) Identify the equipment (type AND size) needed for the experiment and include the name and an image of each. Be sure to describe the equipment, how to use it, and why it is suitable for this use.

Equipment Name	Equipment Picture	Intended Purpose

17.3: Data and Analysis

Data Collection

1. (Acquiring competencies) Following your detailed protocol based on the videos, perform all the experiments. Record your observations and take pictures of your key steps in the process. Your observations and images need to be incorporated in your data section and this section should be as detailed as possible as you will use this information to complete your discussion.
2. (Acquiring competencies) Follow the change in temperature until the ice is fully melted and the temperature doesn't go down any further. If this takes more than 15 minutes or the temperature goes below 4 ºC, start the experiment again with more water. You are encouraged to record your temperature values at specific time intervals (ex. every minute) to keep track of the amount of time that elapsed from the moment you put the ice in the water and the moment thermal equilibrium was established.
3. (Representation) Prepare a table for the data in experiment 1 showing the temperature after each minute. At 0 minutes it will have the temperature of the DI water in the cup.
4. (Representation) Prepare a table for the data in experiment 2 showing the temperature after each minute. At 0 minutes it will have the temperature of the DI water in the cup.

Data Processing

1. (Analysis) Looking at your data for experiment 1, identify the temperature at thermal equilibrium, which is the final temperature of your combined water and melted ice.
2. (Representation) On a piece of paper, draw a large heating curve for water in black ink. Label the y-axis as temperature, and the x-axis as heat added. Mark the freezing and boiling points for water on the temperature axis.
3. (Representation) The graph will look like a series of steps. Label each slanted line in black ink with the appropriate expression for finding the heat absorbed or released during a temperature change. Please, include the state of the substance for which the specific heat constant is used.
4. (Representation) For the horizontal lines, indicate the connected phases in black ink. Then, label each horizontal line with the expression for the heat evolved or absorbed in that phase change. Include any constants that are used.
5. (Representation) Mark the changes that the cooling of the water underwent in blue and the changes the ice underwent in red. They should meet in one point on the graph.
6. (Manipulation) Using your recorded masses, initial and final temperatures, and assuming that the melting ice was at 0.0ºC, calculate the enthalpy of fusion of ice.
7. (Analysis) Looking at your data for experiment 2, identify the temperature at thermal equilibrium, which is the final temperature of your combined water and melted ice.
8. (Representation) On a piece of paper, draw a large heating curve for water in black ink. Label the y-axis as temperature, and the x-axis as heat added. Mark the freezing and boiling points for water on the temperature axis.
9. (Representation) The graph will look like a series of steps. Label each slanted line in black ink with the appropriate expression for finding the heat absorbed or released during a temperature change. Please include the state of the substance for which the specific heat constant is used.
10. (Representation) For the horizontal lines, indicate the connected phases in black ink. Then, label each horizontal line with the expression for the heat evolved or absorbed in that phase change. Include any constants that are used.
11. (Representation) Mark the changes that the cooling of the water underwent in blue and the changes the ice underwent in red. They should meet in one point on the graph.
12. (Manipulation) Using your recorded masses, initial and final temperatures, assuming that the ice was originally at your freezer's temperature, the melting point of ice is 0ºC, and the enthalpy of fusion is 6.01 kJ/mol, calculate the specific heat of ice.
13. (Assumptions and Analysis) Fill in the following table using the observations and data from your experiments.

Assumptions made	Testing the assumption	If assumptions are wrong ...

Assumptions made	Testing the assumption	If assumptions are wrong ...
Ice melts at 0.0°C.	Freeze the water in the freezer and record the temperature when it melts.	
Ice from distilled water and tap water will have the same melting point.		

17.4: Discussion

Discussion

Write a minimum one-page (12 font, single spaced) discussion on the experiment conducted this week. Address **at least one question in each category** as fully as possible integrating the collected data, providing explanations for the observed trends, and evaluating whether your original assumptions about the experiment were validated by the results. **The assignment will be graded on completeness, clarity of the explanations and the meaningful integration of the collected and calculated data.** Correct grammar and appropriate format for the chemical formulae and chemical reactions is expected. **You may use the outline included at the end of this document on how to build your essay to address each category.**

1. (Existing knowledge, research, and views) Define thermal equilibrium.
2. (Acquiring competencies) Describe how a coffee cup calorimeter was used to study thermal equilibrium.
3. (Acquiring competencies) Describe at least 3 properties of Styrofoam cups that make them suitable for these experiments.
4. (Representation and interpretation) Write the formula for calculating heat using specific heat capacity and explain what it means.
5. (Representation and interpretation) Write the formula for calculating heat using the enthalpy of fusion and explain what it means.
6. (Representation and interpretation) Write the formula for the mathematical expression describing thermal equilibrium between the system and the calorimeter and explain what it means.
7. (Analysis) Compare your value for the enthalpy of fusion to the values of the other groups. Evaluate the precision of your measurements.
8. (Analysis) Compare your value for the enthalpy of fusion to the literature value of 6.01 kJ/mol. Evaluate the accuracy of your measurements.
9. (Analysis) Compare your value for the specific heat of ice to the values of the other groups. Evaluate the precision of your measurements.
10. (Analysis) Compare your value for the specific heat of ice to the literature value of 2.108 J/(g×°C). Evaluate the accuracy of your measurements.
11. (Assumptions and limitations) Describe at least one assumption that you made about the ice cube in experiment 1. Evaluate how the final temperature of the cold water would be affected if your assumption is not valid.
12. (Analysis) Provide at least one reason why we had to wait for the temperature to remain constant before terminating each experiment. Evaluate how not waiting would affect the values for the enthalpy of fusion and the specific heat for ice.
13. (Analysis) Would you expect the calculated values for the enthalpy of fusion and the specific heat of ice to change, if you started the experiment with colder or warmer water in the cup? Provide at least one reason for your choice.

CHAPTER OVERVIEW

18: Gas Laws- Popcorn

18.1: Video Links

Consider before watching the videos:

If a can is inverted in a tub of water, what is the pressure inside the can?

VIDEO LINKS:

Lab Experiments (Write protocols based on the videos then complete your protocols as you perform experiments in class):

1. Gas Laws: Popcorn

2. Imploding the Soda Can

Data analysis and calculations (Use these if you need help with your data and calculations)

1. Ideal Gas Law

Demonstration (For entertainment):

1. Pharaoh's Serpent Demonstration

2. Ammonia Fountain Demonstration

18.2: Experimental Protocol and Tables (Prelab)

Experimental Protocol (10 points)

Write out the protocol for each part of the experiment. (It can be written in sequential steps. Complete sentences are not necessary.) This is the protocol you follow, so be detailed.

Chemical Table (5 points)

Prepare your chemical table including the materials you use in the experiment. Here is a general template that you may use.

Chemical Name	Chemical Formula	Molar Mass (g/mol)	Hazards	reference	PPE
Sodium Chloride	**NaCl**	**58.5**	**Skin irritation**	**https://fscimage.fishersci.com/msds/21105.htm**	

Equipment Table (5 points)

Identify the equipment (type AND size) needed for the experiment and include the name and an image (picture) of each. Be sure to describe the equipment, how to use it, and why it is suitable for this use.

Equipment Name	Equipment Picture	Intended Purpose

18.3: Data and Analysis

Data Collection (25 points)

Following your detailed protocol, perform all the experiments. Record your observations and take pictures of your key steps in the process. Your observations and images need to be incorporated in your data section and this section should be as detailed as possible as you will use this information to complete your discussion.

Data Processing (25 points)

1. What percent of the kernels did not pop (open at all)?
2. Assuming that minimal water is absorbed by the kernels, show the calculation for finding the volume of the kernels in milliliters and liters.
3. Assuming that minimal water is absorbed by the kernels, show the calculation for finding the mass of the kernels in grams.
4. Assuming that water vapor is the only gas released by popping popcorn, calculate the total mass of water released by popping.
5. Assuming that minimal water is absorbed by the kernels, calculate the percent water in your kernels.
6. Calculate the moles of water released in your popping experiment.
7. Assuming T to be the boiling point (smoke point) of the oil you are using, find T in Kelvin (around 400oF).
8. Using your measured kernel volume, calculated moles of water released and your temperature of boiling oil, calculate the expected pressure inside your kernels.
9. Fill in the following table using the data and observations from your experiment:

Assumptions made	Testing the assumption	If assumptions are wrong ...

18.4: Discussion

Discussion (30 points)

Write a minimum one-page (12 font, single spaced) discussion on the experiment conducted this week. **The assignment will be graded on completeness, clarity of the explanations and the meaningful integration of the collected and calculated data.** Correct grammar and appropriate format for the chemical formulae and chemical reactions is expected. **You may use the outline included at the end of this document on how to build your essay to address each category.**

1. Define ideal gases in your own words and describe the conditions under which a gas will behave as an ideal gas.
2. Describe your experimental conditions and compare them to the conditions described in your answer to Question 1. Explain how this knowledge influences the type of equations that you can use to do your calculations.
3. Describe and explain the method you used to identify the volume of the kernels. Explain why the volume of the kernels was only found before popping, but after popping was not found. Use your calculated values to support your arguments.
4. Identify at least one assumption that you made about the volume of water in the kernel. (HINT: there are other things in a kernel).
5. Propose at least one way the volume occupied by water inside of a kernel could be more accurately determined.
6. Give a supported argument for why this experiment should be done with more than one kernel.
7. Explain why oil is used.
8. Explain why the inside of the flask was wiped before the mass was recorded.
9. Compare the pressure values calculated with others either in your lab or check the internet for results and note your sources. Comment on the accuracy and precision of the experiment.
10. Predict and explain the result of placing the kernels in an over at low temperature for two hours prior to performing this experiment versus soaking the kernels for 2 hours in water prior to performing the experiment.
11. Propose at least one modification that would improve this experiment.
12. Identify the pressure in an unopened can of soda.
13. Find the maximum pressure a soda can is able to resist before exploding.
14. If you leave a closed can in a 120°F temperature car, will it explode?
15. Identify the pressure in an open can of soda before and after boiling the water.
16. Comment on what happened to the pressure inside the can after it was turned into the water bath.
17. Look up the definition of phreatic eruption and comment on whether its more similar to the explosion of the popcorn or the implosion of the soda can.

Recommended discussion outline:

The concepts I used in this experiment were…

The most important aspect of this experiment was…

The purpose of the experiment was (Hint: it was not to make things explode) … By performing this experiment, I learned…

CHAPTER OVERVIEW

19: Law of Mass Conservation

19.1: Video Links

Consider before watching the videos:

What happens to matter during chemical reactions?

VIDEO LINKS:

Lab Experiments (Write protocols based on the videos then complete your protocols as you perform experiments in class):

1. Reaction of Sodium Carbonate with Calcium Chloride

2. Filtering the Product Mixture

3. Recovering the Products

Data analysis and calculations (Use these if you need help with your data and calculations)

1. Chemical Reactions

2. Stoichiometry

19.2: Experimental Protocol and Tables (Prelab)

Experimental Protocol (10 points)

Write out the protocol for each part of the experiment. (It can be written in sequential steps. Complete sentences are not necessary.) This is the protocol you follow, so be detailed.

Chemical Table (5 points)

Prepare your chemical table including the materials you use in the experiment. Here is a general template that you may use.

Chemical Name	Chemical Formula	Molar Mass (g/mol)	Hazards	reference	PPE
Sodium Chloride	**NaCl**	**58.5**	**Skin irritation**	**https://fscimage.fishersci.com/msds/21105.htm**	

Equipment Table (5 points)

Identify the equipment (type AND size) needed for the experiment and include the name and an image (picture) of each. Be sure to describe the equipment, how to use it, and why it is suitable for this use.

Equipment Name	Equipment Picture	Intended Purpose

19.3: Data and Analysis

Data Collection (25 points)

Following your detailed protocol, perform all the experiments. Record your observations and take pictures of your key steps in the process. Your observations and images need to be incorporated in your data section and this section should be as detailed as possible as you will use this information to complete your discussion.

Data Processing (25 points)

1. Write the balanced chemical equation for the reaction for sodium carbonate with calcium chloride.
2. Starting with the molecular equation, use your knowledge of dissociation reactions to derive the complete ionic and net ionic equations.
3. Classify the type of reaction that occurs between calcium chloride and sodium carbonate.
4. Calculate the total mass of the reactants.
5. Calculate the mass of all the products collected after the reaction (Hint: the sum of the material from the filter paper + the material left in the beaker)?
6. Starting with the mass of calcium chloride, calculate the expected mass of calcium carbonate and sodium chloride from the reaction.
7. Starting with the mass of sodium carbonate, calculate the expected mass of calcium carbonate and sodium chloride from the reaction.
8. Calculate the percent yield of calcium carbonate.
9. Calculate the percent yield of sodium chloride.
10. Fill in the following table using the data and observations from your experiment:

Assumptions made	Testing the assumption	If assumptions are wrong ...
The distilled water is pure	Evaporate it and check for residue	
Only Na_2CO_3 is present in a container labelled Na_2CO_3		

19.4: Discussion

Discussion (30 points)

Write a minimum one-page (12 font, single spaced) discussion on the experiment conducted this week. **The assignment will be graded on completeness, clarity of the explanations and the meaningful integration of the collected and calculated data.** Correct grammar and appropriate format for the chemical formulae and chemical reactions is expected. **You may use the outline included at the end of this document on how to build your essay to address each category.**

1. Define conservation of mass.
2. Give an argument based on your results for classifying the reaction that took place.
3. In your experiment, was conservation of mass observed?
4. Using pictures from your lab, explain any discrepancies observed between the mass of starting materials and end products.
5. Why do we rinse the beaker after transferring the solution into another beaker?
6. Describe the steps involved in filtration.
7. Why do you rinse the filter paper during filtration?
8. Why does the salt jump out of the beaker when the solution is evaporated?
9. Describe when filtration is best used.
10. Provide at least 2 additional balanced chemical equations for the same class of reaction as the reaction of calcium chloride with sodium carbonate.
11. Give at least two examples of how this class of reactions are present in your life.

Recommended discussion outline:

The concepts I used in this experiment were…

The most important aspect of this experiment was…

The purpose of the experiment was (Hint: it was not to determine the products of a reaction) … By performing this experiment, I learned…

CHAPTER OVERVIEW

20: Mass, Volume and Density

20.1: Video Links

Consider before watching the videos:

Does a pound of feathers weigh the same amount as a pound of bricks? Does a pound of feathers have the same volume as a pound of oranges?

VIDEO LINKS:

Lab Experiments (Write protocols based on the videos then complete your protocols as you perform experiments in class):

1. Weighing

2. Measuring Volume

Data analysis and calculations (Use these if you need help with your data and calculations)

1. Measurements

2. Significant figures

20.2: Experimental Protocol and Tables (Prelab)

For today the prelab will be written as a group at the beginning of class. Future pre-labs will be due before your lab class meets and will include Experimental Protocol, Chemical Table and Equipment Table.

Experimental Protocol (10 points)

Write out the protocol for each part of the experiment. (It can be written in sequential steps. Complete sentences are not necessary.) This is the protocol you follow, so be detailed.

Part 1: Find the mass of a regular object.

Part 2: Find the volume of a regular object.

Part 3: Find the mass of an irregular object.

Part 4: Find the volume of an irregular object.

Part 5: Find the density of a regular and an irregular object.

Chemical Table (5 points)

Prepare your chemical table including the materials you use in the experiment. Here is a general template that you may use.

Chemical Name	Chemical Formula	Molar Mass (g/mol)	Hazards	reference	PPE
Sodium Chloride	**NaCl**	**58.5**	**Skin irritation**	https://fscimage.fishersci.com/msds/21105.htm	

Equipment Table (5 points)

Identify the equipment (type AND size) needed for the experiment and include the name and an image (picture) of each. Be sure to describe the equipment, how to use it, and why it is suitable for this use.

Equipment Name	Equipment Picture	Intended Purpose

20.3: Data and Analysis

Data Collection (25 points)

Following your detailed protocol, perform all the experiments. Record your observations and take pictures of your key steps in the process. Your observations and images need to be incorporated in your data section and this section should be as detailed as possible as you will use this information to complete your discussion.

Take every measurement 3 times and then average the values for best accuracy. Find both the mass and the volume for every object you investigate.

Part 1: Find the mass of a regular object.

Object name	Mass 1	Mass 2	Mass 3	Average

Part 2: Find the volume of a regular object.

Object name	length	Width	Height	Volume
	Average	Average	Average	Average
	Average	Average	Average	Average

Part 3: Find the mass of an irregular object.

Object name	Mass 1	Mass 2	Mass 3	Average

Part 4: Find the volume of an irregular object.

Object name	Initial Volume	Final Volume	Difference

Object name	Initial Volume	Final Volume	Difference
	Average	Average	Average
	Average	Average	Average

Data Processing (25 points)

1.Find the density of a regular and an irregular object:

Object name	Mass	Volume	Density	Known value

2. Calculate the % error in the density calculations using the following formula:

$$\% \text{ error } = \frac{(\text{ experimental value } - \text{ true value })}{\text{true value}} \times 100\%$$

Make this number positive (take the absolute value). Your instructor will have the true values.

3. Fill in the following table using the observations and data from your experiments.

Assumptions made	Testing the assumption	If assumptions are wrong ...
The distilled water is pure	Evaporate it and check for residue	The density would change depending on the density of the contaminant
The objects used for displacement does not absorb water	Take the mass before placing in water and again after it was removed form water and dried	
Mass shown on the scale is accurate		Different scales show different mass for the same object

20.4: Discussion

Discussion (30 points)

For the discussion you have two options:

1. Answer each question below in sufficient detail to address each task, so more than 1-2 sentences.

2. Write a minimum half-page (12 font, single spaced) discussion on the experiment conducted this week. **The assignment will be graded on completeness, clarity of the explanations and the meaningful integration of the collected and calculated data.** Correct grammar and appropriate format for the chemical formulae and chemical reactions is expected. **You may use the outline included at the end of this document on how to build your essay to address each category.**

1. Using at least one of your recorded mass and volume measurements, identify its required components (number and unit).
2. Identify the number of significant figures in all your recorded measurements. Describe what process you used to decide how many numbers were significant.
3. Describe how you measured the volume of the regular and irregular objects. Use one of your measurements for each to demonstrate the process.
4. Describe how you calculated the density of the regular and irregular objects. Use one of each of your calculations to demonstrate the process.
5. Give a supported argument for whether density is affected by the amount of material in your sample.
6. Use one your density calculations as an example to show how you determined the number of significant figures in your answer.
7. Propose another experiment to determine the density of something that interests you around your house. Testing your proposed method is a good way to ensure that you are correct. Don't hesitate to share your pictures!

Recommended discussion outline:

The techniques I used in this experiment were…

By dividing the mass by the volume, the amount of each was no longer important because…

In this experiment we assumed ....

The purpose of the experiment was (Hint: it was not to find the density of a bunch of random objects) … By performing this experiment, I learned…

CHAPTER OVERVIEW

21: Paper Chromatography

21.1: Video Links

Consider before watching the videos:

Is it possible to separate pen ink colors, candy colors or food dye colors into their components?

VIDEO LINKS:

Lab Experiments (Write protocols and perform experiments based on these):

1. Paper Chromatography

21.2: Experimental Protocol and Tables (Prelab)

The pre-lab must include Experimental Protocol, Chemical Table and Equipment Table. The lab report includes all sections.

Experimental Protocol (10 points)

Watch the experimental videos. Take notes on the protocol. Stop the video and re-watch as necessary to acquire the details of the procedure. Write out the protocol for each part of the experiment. (It can be written in sequential steps. Complete sentences are not necessary.) This is the protocol you follow, so be detailed.

Chemical Table (5 points)

Prepare your chemical table including the materials you use in the experiment. Here is a general template that you may use.

Chemical Name	Chemical Formula	Molar Mass (g/mol)	Hazards	reference	PPE
Sodium Chloride	**NaCl**	**58.5**	**Skin irritation**	**https://fscimage.fishersci.com/msds/21105.htm**	

Equipment Table (5 points)

Identify the equipment (type AND size) needed for the experiment and include the name and an image (picture) of each. Be sure to describe the equipment, how to use it, and why it is suitable for this use.

Equipment Name	Equipment Picture	Intended Purpose

21.3: Data and Analysis

Data Collection (25 points)

Following your detailed protocol, perform all the experiments. Record your observations and take pictures of your key steps in the process. Your observations and images need to be incorporated in your data section and this section should be as detailed as possible as you will use this information to complete your discussion.

Water

Food color	Color 1 with range	Color 2 with range	Color 3 with range
Red			
Yellow			
Green			
blue			
Solvent front			

Salt Water

Food color	Color 1 with range	Color 2 with range	Color 3 with range
Red			
Yellow			
Green			
blue			
Solvent front			

Isopropyl alcohol

Food color	Color 1 with range	Color 2 with range	Color 3 with range
Red			
Yellow			
Green			
blue			
Solvent front			

Water

Candy	Color 1 with range	Color 2 with range	Color 3 with range

Candy	Color 1 with range	Color 2 with range	Color 3 with range
Solvent front			

Salt Water

Candy	Color 1 with range	Color 2 with range	Color 3 with range
Solvent front			

Isopropyl alcohol

Candy	Color 1 with range	Color 2 with range	Color 3 with range
Solvent front			

Data Processing (25 points)

1. To compare data between groups, how are the distances from the starting line standardized to take into account different run times?
2. What are the primary colors? What are secondary colors?
3. Provide evidence to indicate whether the primary colors of the food dye were made up of a single-color dye.
4. Why did you use 3 different solvents to investigate your dye colors?
5. Did all the solvents move at the same speed up the paper? Explain.
6. Fill in the following table using the observations and data from your

Assumptions made	Testing the assumption	If assumptions are wrong ...
The distilled water is pure	Evaporate it and check for residue	The density would change depending on the density of the contaminant
Food color is water soluble	Try dissolving food color in nonpolar solvent	

Assumptions made	Testing the assumption	If assumptions are wrong ...
Candy dye separates into component colors in water		Only one color will be observed

21.4: Discussion

Discussion (30 points)

Write a minimum one-page (12 font, single spaced) discussion on the experiment conducted this week. **The assignment will be graded on completeness, clarity of the explanations and the meaningful integration of the collected and calculated data.** Correct grammar and appropriate format for the chemical formulae and chemical reactions is expected. **You may use the outline included at the end of this document on how to build your essay to address each category.**

1. What would you predict would happen if the filter paper were replaced with another medium (like paper towel, or silica gel, plastic sheets or sand)?
2. Describe at least one more application of paper chromatography.
3. What determines how far the color moves?
4. What determines how far the solvent moves?
5. Why should you cover the chamber when doing paper chromatography?
6. What is the stationary phase in the experiment?
7. What are the drawbacks of paper chromatography?
8. How does paper chromatography work?
9. What experiment would you like to try using paper chromatography?

Recommended discussion outline:

The concepts I used in this experiment were…

The most important aspect of this experiment was…

The purpose of the experiment was (Hint: it was not to determine the colors making up food dye) … By performing this experiment, I learned…

CHAPTER OVERVIEW

22: Reproducing a Protocol

22.1: Video Links

Consider before watching the videos:

How detailed should a record of experimental procedure and results be in a lab experiment?

VIDEO LINKS:

Lab Experiments (Write protocols based on the videos then complete your protocols as you perform experiments in class):

1. Weighing

2. Measuring Volume

3. Making Slime:

Data analysis and calculations (Use these if you need help with your data and calculations)

1. Measurements

2. Significant figures

22.2: Experimental Protocol and Tables (Prelab)

Bring 2 printed copies of your protocol developed during the Developing a Protocol session.

22.3: Data and Analysis

Data Collection (25 points)

Following your detailed protocol, perform all the experiments. Record your observations and take pictures of your key steps in the process. Your observations and images need to be incorporated in your data section and this section should be as detailed as possible as you will use this information to complete your discussion.

Part 1: Create slime using the best protocol you created from your last lab class.

Presented protocol: (include the protocol from your own group in as much detail as was presented)

Ingredients	Amount required	Texture	Picture
Glue			
Water			
Baking soda			
Shaving cream			
Contact solution			
Food color			

Performed protocol: (add any details that you added to the presented protocol when it wasn't explicit: ex. stirring, order of mixing, length of time between additions, mixes, etc.)

Ingredients	Amount added	Texture	Picture
Glue			
Water			
Baking soda			
Shaving cream			
Contact solution			
Food color			

Part 2: Create slime using the protocol from another group that was created in your last lab class.

Presented protocol: (include the protocol from the other group in as much detail as was presented)

Ingredients	Amount required	Texture	Picture
Glue			
Water			
Baking soda			

Ingredients	Amount required	Texture	Picture
Shaving cream			
Contact solution			
Food color			

Performed protocol attempt 1: (add any details that you added to the presented protocol when it wasn't explicit: ex. stirring, order of mixing, length of time between additions, mixes, etc.)

Ingredients	Amount added	Texture	Picture
Glue			
Water			
Baking soda			
Shaving cream			
Contact solution			
Food color			

Performed protocol attempt 2: (add any details that you added to the presented protocol when it wasn't explicit: ex. stirring, order of mixing, length of time between additions, mixes, etc.)

Ingredients	Amount added	Texture	Picture
Glue			
Water			
Baking soda			
Shaving cream			
Contact solution			
Food color			

Data Processing (25 points)

1. Identify the variable(s) that you changed in the slime-making experiment.

2. Describe the effect each change had on the created slime (texture, color, stretchability, stickiness, etc.) (You may use pictures as supporting evidence, just make sure that you add captions to each image.)

3. Compare your slime from last lab class to the slime you made today following your own protocol. (You may use pictures as supporting evidence, just make sure that you add captions to each image.)

4. Compare your slime that you created following another team's protocol to the slime the other team created following their own protocol. (You may use pictures as supporting evidence, just make sure that you add captions to each image.)

5. Compare your slime that you created following your own protocol to the slime another team created following your protocol.

6. Fill in the following table using the observations and data from your experiments.

Assumptions made	Testing the assumption	If assumptions are wrong ...

Assumptions made	Testing the assumption	If assumptions are wrong ...
The glue will behave the same way regardless of brand	Try different brands of glue.	
Contact solution brand has no impact		Different contact solutions show different results
The distilled water is pure	Evaporate it and check for residue	The density would change depending on the density of the contaminant
The container has no effect on the slime texture	Try different containers.	

22.4: Discussion

Discussion (30 points)

Write a minimum one-page (12 font, single spaced) discussion on the experiment conducted this week. **The assignment will be graded on completeness, clarity of the explanations and the meaningful integration of the collected and calculated data.** Correct grammar and appropriate format for the chemical formulae and chemical reactions is expected. **You may use the outline included at the end of this document on how to build your essay to address each category.**

1. Slime is a polymer. Define a polymer and give at least 3 other examples of polymers you encounter every day.
2. Identify the role of the contact solution, glue, and baking soda in the slime formulation.
3. Describe how you varied on component while holding the others constant in the process.
4. Give a supported argument why it is important to vary only one component at a time in an experiment.
5. Propose another experiment to modify your slime protocol. Don't hesitate to test your protocol and share your pictures!
6. Identify at least one other area of your life where having a clear and detailed protocol is essential. Don't hesitate to provide a sample protocol!
7. Based on your experience reproducing your own and your colleagues' experiments, describe how much detail was or would have been helpful in the provided protocol to confidently perform the experiment.
8. Based on your experience reproducing your own and your colleagues' experiments, describe how much detail was or would have been helpful in the description of the product to make you confident in your ability to reproduce their results.
9. Describe at least one take-away from this experiment that you will use to improve your experimental protocols or data collection process for future experiments.

Recommended discussion outline:

In this experiment I ….

The techniques I used in this experiment were…

The role of each of the ingredients in creating the slime were as follows:

The most important aspect of this experiment was…

In this experiment we assumed ....

The purpose of the experiment was (Hint: it was not to make slime) … By performing this experiment, I learned…

CHAPTER OVERVIEW

23: Soap

23.1: Video Links

Consider before watching the videos:

What kind of ingredients are used to make soap bars? What about liquid soap?

VIDEO LINKS:

Lab Experiments (Write protocols based on the videos then complete your protocols as you perform experiments in class):

1. Making Soap

2. Testing the Soap

Data analysis and calculations (Use these if you need help with your data and calculations)

1. Soap

23.2: Experimental Protocol and Tables (Prelab)

Experimental Protocol (10 points)

Write out the protocol for each part of the experiment. (It can be written in sequential steps. Complete sentences are not necessary.) This is the protocol you follow, so be detailed.

Chemical Table (5 points)

Prepare your chemical table including the materials you use in the experiment. Here is a general template that you may use.

Chemical Name	Chemical Formula	Molar Mass (g/mol)	Hazards	reference	PPE
Sodium Chloride	**NaCl**	**58.5**	**Skin irritation**	**https://fscimage.fishersci.com/msds/21105.htm**	

Equipment Table (5 points)

Identify the equipment (type AND size) needed for the experiment and include the name and an image (picture) of each. Be sure to describe the equipment, how to use it, and why it is suitable for this use.

Equipment Name	Equipment Picture	Intended Purpose

23.3: Data and Analysis

Data Collection (25 points)

Following your detailed protocol, perform all the experiments. Record your observations and take pictures of your key steps in the process. Your observations and images need to be incorporated in your data section and this section should be as detailed as possible as you will use this information to complete your discussion.

Reactants	Initial amounts Trial 1	Initial amount Trial 2
NaOH		
DI water		
Ethanol		
Oil type		

Test	Observations	Bubble layer height (cm)
DI water		
Tap Water		
$CaCl_2$ solution		

Data Processing (25 points)

1. Write the balanced chemical reaction for the formation of soap.
2. Classify the reagents for all the reactions.
3. Classify the reaction types for all the reactions.
4. What is the pH of your soap?
5. Fill in the following table using the data and observations from your experiment:

Assumptions made	Testing the assumption	If assumptions are wrong ...
The distilled water is pure	Evaporate it and check for residue	The density would change depending on the density of the contaminant.
Any oil will form soap	Run the reaction on many different oils	

23.4: Discussion

Discussion (30 points)

Write a minimum one-page (12 font, single spaced) discussion on the experiment conducted this week. **The assignment will be graded on completeness, clarity of the explanations and the meaningful integration of the collected and calculated data.** Correct grammar and appropriate format for the chemical formulae and chemical reactions is expected. **You may use the outline included at the end of this document on how to build your essay to address each category.**

1. Define saponification.
2. Why did you use a sand bath instead of a hot plate or Bunsen burner?
3. What would happen if you left your soap exposed to the air?
4. What is hard water?
5. What is tap water?
6. What is deionized water?
7. What is distilled water?
8. What is the difference between distilled, deionized, tap and hard water?
9. Which type of water would produce the most bubbles?
10. What is a micelle?
11. How does soap work in cleaning?
12. Which type of water would be the best for cleaning?
13. What is another experiment that you wish you would have done with soap?
14. At craft shows people often advertise that their soap is made without lye. What does that mean? Should you believe them?

Recommended discussion outline:

The concepts I used in this experiment were…

The most important aspect of this experiment was…

The purpose of the experiment was (Hint: it was not to make soap) … By performing this experiment, I learned…

CHAPTER OVERVIEW

24: Solubility of Ionic Compounds

24.1: Video Links

Consider before watching the videos:

Is it possible to predict if a material will be soluble in water?

VIDEO LINKS:

Lab Experiments (Write protocols based on the videos then complete your protocols as you perform experiments in class):

1. Solubility of Ionic Compounds

Data analysis and calculations (Use these if you need help with your data and calculations)

1. Solubility

2. Dissociation vs. Ionization

24.2: Experimental Protocol and Tables (Prelab)

Experimental Protocol (10 points)

Write out the protocol for each part of the experiment. (It can be written in sequential steps. Complete sentences are not necessary.) This is the protocol you follow, so be detailed.

Chemical Table (5 points)

Prepare your chemical table including the materials you use in the experiment. Here is a general template that you may use.

Chemical Name	Chemical Formula	Molar Mass (g/mol)	Hazards	reference	PPE
Sodium Chloride	**NaCl**	**58.5**	**Skin irritation**	**https://fscimage.fishersci.com/msds/21105.htm**	

Equipment Table (5 points)

Identify the equipment (type AND size) needed for the experiment and include the name and an image (picture) of each. Be sure to describe the equipment, how to use it, and why it is suitable for this use.

Equipment Name	Equipment Picture	Intended Purpose

24.3: Data and Analysis

Data Collection (25 points)

Following your detailed protocol, perform all the experiments. Record your observations and take pictures of your key steps in the process. Your observations and images need to be incorporated in your data section and this section should be as detailed as possible as you will use this information to complete your discussion.

Compound	Mass of compound (g)	Volume of water (mL)	Soluble or Insoluble
NaCl			
$CaCl_2$			
$MgCl_2$			
Na_2SO_4			
$CaSO_4$			
$MgSO_4$			
Na_2CO_3			
$CaCO_3$			
$MgCO_3$			

Data Processing (25 points)

1. Write the balanced equation for the dissolution each ionic compound in water that you tested.

Compound	Dissociation reaction
NaCl	$NaCl(s) \rightarrow$
$CaCl_2$	
$MgCl_2$	
Na_2SO_4	
$CaSO_4$	
$MgSO_4$	
Na_2CO_3	
$CaCO_3$	
$MgCO_3$	

2. Fill in the following table using the data and observations from your experiment:

Assumptions made	Testing the assumption	If assumptions are wrong ...
The distilled water is pure	Evaporate it and check for residue	The density would change depending on the density of the contaminant
A laser pointer can identify a solution		

Assumptions made	Testing the assumption	If assumptions are wrong ...

24.4: Discussion

Discussion (30 points)

Write a minimum one-page (12 font, single spaced) discussion on the experiment conducted this week. **The assignment will be graded on completeness, clarity of the explanations and the meaningful integration of the collected and calculated data.** Correct grammar and appropriate format for the chemical formulae and chemical reactions is expected. **You may use the outline included at the end of this document on how to build your essay to address each category.**

1. What does soluble and insoluble mean?
2. How is solubility expressed?
3. Why was it necessary to swirl or stir the solutions?
4. Compare the solubility of your compounds with the same cation. What similarities and differences did you find?
5. Compare the solubility of your compounds with the same anion. What similarities and differences did you find?
6. What process is used to determine the solubility of a compound?
7. Suggest another experimental protocol to determine the solubility of a series of related compounds.
8. Insert the picture of a solubility table and include the reference to the source.
9. How do your results from the experiment compare to the solubility table above?
10. Check the ingredient labels of the products (shampoo, laundry detergent, etc.) in your home and identify the most common cations in them. Provide a reason based on your experiment for why this most common cation is suitable for these products.
11. Check the ingredient labels of the foods and drinks in your home and identify the most common cations in them. Provide a reason based on your experiment for why this most common cation is suitable for these products.
12. Pretend that you are a food scientist planning to replace sodium with calcium in a drink. Describe at least one challenge that you can foresee and provide at least one recommendation for addressing it.

Recommended discussion outline:

The concepts I used in this experiment were…

The most important aspect of this experiment was…

The purpose of the experiment was (Hint: it was not to determine the solubility of specific salts) … By performing this experiment, I learned…

CHAPTER OVERVIEW

25: Spherification

25.1: Video Links

Consider before watching the videos:

Why do gels form smooth spherical shapes rather than squares or triangles?

VIDEO LINKS:

Lab Experiments (Write protocols based on the videos then complete your protocols as you perform experiments in class):

1. Spherification

Data analysis and calculations (Use these if you need help with your data and calculations)

1. Spherification tutorial

25.2: Experimental Protocol and Tables (Prelab)

Experimental Protocol (10 points)

Write out the protocol for each part of the experiment. (It can be written in sequential steps. Complete sentences are not necessary.) This is the protocol you follow, so be detailed.

Chemical Table (5 points)

Prepare your chemical table including the materials you use in the experiment. Here is a general template that you may use.

Chemical Name	Chemical Formula	Molar Mass (g/mol)	Hazards	reference	PPE
Sodium Chloride	**NaCl**	**58.5**	**Skin irritation**	**https://fscimage.fishersci.com/msds/21105.htm**	

Equipment Table (5 points)

Identify the equipment (type AND size) needed for the experiment and include the name and an image (picture) of each. Be sure to describe the equipment, how to use it, and why it is suitable for this use.

Equipment Name	Equipment Picture	Intended Purpose

25.3: Data and Analysis

Data Collection (25 points)

Following your detailed protocol, perform all the experiments. Record your observations and take pictures of your key steps in the process. Your observations and images need to be incorporated in your data section and this section should be as detailed as possible as you will use this information to complete your discussion.

Data Processing (25 points)

1. Write the balanced chemical reaction for $\mathrm{CaCl_2}$ dissolving in water.
2. Calculate the concentration of $\mathrm{CaCl_2}$ in solution.
3. Calculate the concentration of $\mathrm{Ca^{2+}}$ and $\mathrm{Cl^-}$ in solution.
4. Calculate the concentration of sodium alginate in solution.
5. Fill in the following table using the data and observations from your experiment:

Assumptions made	Testing the assumption	If assumptions are wrong ...
The distilled water is pure	Evaporate it and check for residue	The density would change depending on the density of the contaminant.
Calcium alginate is insoluble in water	Check the solubility	
		The mass of recovered solid is dramatically less then expected

25.4: Discussion

Discussion (30 points)

Write a minimum one-page (12 font, single spaced) discussion on the experiment conducted this week. **The assignment will be graded on completeness, clarity of the explanations and the meaningful integration of the collected and calculated data.** Correct grammar and appropriate format for the chemical formulae and chemical reactions is expected. **You may use the outline included at the end of this document on how to build your essay to address each category.**

1. What is spherification?
2. What is sodium alginate used for in daily life? Give at least 2 examples.
3. In what way are the sodium alginate and calcium chloride solutions similar?
4. In what way are the sodium alginate and calcium chloride solutions different?
5. What did you observe over time when popping your spheres?
6. What causes the formation of the spheres?
7. What causes the hardening of the spheres?
8. What determines the shape of the spheres?
9. What would you expect to happen to the spheres if they remain in the air?
10. Were you able to make shapes other than spheres? If yes, how?
11. If you wanted to make other shapes on purpose, how would you do it?
12. What do you think will happen if you added the calcium chloride solution to the sodium alginate solution?
13. What other experiments would you like to conduct on the sodium alginate system?

Recommended discussion outline:

The concepts I used in this experiment were…

The most important aspect of this experiment was…

The purpose of the experiment was (Hint: it was not to make gel spheres) … By performing this experiment, I learned…

CHAPTER OVERVIEW

26: Thermochemistry

26.1: Video Links

Consider before watching the videos:

What is sugar? Is there any similarity between sugar and paper?

VIDEO LINKS:

Lab Experiments (Write protocols based on the videos then complete your protocols as you perform experiments in class):

1. Making Caramel

2. Black Snake

3. Invisible Ink with Sodium Nitrate

Data analysis and calculations (Use these if you need help with your data and calculations)

1. Fire

26.2: Experimental Protocol and Tables (Prelab)

Experimental Protocol (10 points)

Write out the protocol for each part of the experiment. (It can be written in sequential steps. Complete sentences are not necessary.) This is the protocol you follow, so be detailed.

Chemical Table (5 points)

Prepare your chemical table including the materials you use in the experiment. Here is a general template that you may use.

Chemical Name	Chemical Formula	Molar Mass (g/mol)	Hazards	reference	PPE
Sodium Chloride	**NaCl**	**58.5**	**Skin irritation**	**https://fscimage.fishersci.com/msds/21105.htm**	

Equipment Table (5 points)

Identify the equipment (type AND size) needed for the experiment and include the name and an image (picture) of each. Be sure to describe the equipment, how to use it, and why it is suitable for this use.

Equipment Name	Equipment Picture	Intended Purpose

26.3: Data and Analysis

Data Collection (25 points)

Following your detailed protocol, perform all the experiments. Record your observations and take pictures of your key steps in the process. Your observations and images need to be incorporated in your data section and this section should be as detailed as possible as you will use this information to complete your discussion.

Part 1: Caramel

Part 2: Black Snake

Part 3: Invisible Ink

Data Processing (25 points)

1. Provide the formula and chemical structure for table sugar.
2. Select all that apply. Table sugar is:
   - An atom
   - An element
   - A molecule
   - A compound
   - An organic compound
   - An inorganic compound
   - An ionic compound
   - Soluble in water
   - Able to react with itself
   - Only able to react with other materials
   - Crystalline
   - Amorphous
3. Select all that apply. Sodium nitrate is:
   - An atom
   - An element
   - A molecule
   - A compound
   - An organic compound
   - An inorganic compound
   - An ionic compound
   - Soluble in water
   - Able to react with itself

Only able to react with other materials

Crystalline

Amorphous

4. Select all that apply. Paper is:

An atom

An element

A molecule

A compound

A mixture

An organic compound

An inorganic compound

An ionic compound

Soluble in water

Able to react with itself

Only able to react with other materials

Crystalline

Amorphous

5. For the black snake experiment, comment on whether the volume is increasing, decreasing, or remaining the same based on your observations.
6. Looking at the product of the black snake experiment, estimate its composition.
7. Fill in the following table using the data and observations from your experiment:

Assumptions made	Testing the assumption	If assumptions are wrong ...
The distilled water is pure	Evaporate it and check for residue	
Sugar is pure		

26.4: Discussion

Discussion (30 points)

Write a minimum one-page (12 font, single spaced) discussion on the experiment conducted this week. **The assignment will be graded on completeness, clarity of the explanations and the meaningful integration of the collected and calculated data.** Correct grammar and appropriate format for the chemical formulae and chemical reactions is expected. **You may use the outline included at the end of this document on how to build your essay to address each category.**

1. Classify making caramel as a physical or chemical change and justify your choice.
2. Classify making the black snake as a physical or chemical change and justify your choice.
3. Classify the invisible ink experiment as a physical or chemical change and justify your choice.
4. Based on your observations how did the same smell from the snake and the caramel experiments compare?
5. Identify and explain the role of baking soda in the black snake experiment.
6. Based on your observations, give a supported prediction as to whether the mass of the product would be greater or less than the starting material in each experiment.
7. Identify at least one factor that is important to control in making caramel.
8. List the 3 components of fire and identify each one in the black snake experiment. (HINT: it is possible to have more than one chemical in each category.)
9. List the 3 components of fire and identify each one in the invisible ink experiment.
10. Provide a supported argument for why drying the paper in the invisible ink experiment was necessary.
11. Identify any similarities between the fuels used in the three experiments.

Recommended discussion outline:

The techniques I used in this experiment were…

This lab is considered qualitative because…

In this experiment we assumed ....

The purpose of the experiment was (Hint: it was not to cook) … By performing this experiment, I learned…

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