Fundamentals of Chemistry I

Laboratory Manual

Department of Chemistry
East Los Angeles College

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Math Review

Part A: Solve each of the following expressions for x.

1. $2x - 25 = 8$

2. $3x = 4y + 8$ *(if y = 2)*

3. $8x + 5y - z = 0$ *(if y = 4 and z = -1)*

4. $H = W\,Q\,x$

5. $Y = \dfrac{(T + 8)}{x}$

6. $x + 6 = 23FG$

7. $\dfrac{C^2D^5x}{E^4R} = \dfrac{T^3K}{Y}$

Part B: Express each of the following in standard numerical form.

1. 7.2×10^3
2. 9.35×10^{-4}
3. 8.3×10^{-2}
5. 2.6×10^1
6. 4.852×10^2
7. 8.57×10^{-1}

Part C: Express each of the following in scientific notation.

1. 87,000
2. 0.00035
3. 280
5. 2547
6. 0.0053
7. 0.013254

Name: ________________________

Part D: Complete the following calculations. Include units on your answers. Report your answer to 1 decimal place.

1. $\frac{(100\ m)}{(26\ s)}$

2. (5.1 m) (4.5 m)

3. $\frac{(58\ g)}{(4\ L)}$

4. (34 cm) (21 cm) (8 cm)

5. $\frac{12500\ J}{(106\ g)\ (4C)}$

6. $\frac{(8.1\ kg)}{(0.45\ cm \times 0.55\ cm)}$

7. 0.45 mm x 0.28 mm x 0.85 mm

8. $\frac{(75\ kg)\ (5.0\ m)}{(2.5\ s)\ (6.0\ s)}$

9. $\frac{26000\ J}{125\ g}$

10. $\frac{1.35\ mol}{3.55\ L}$

Part E Simplify the following expressions.

1. (4f + 13g) (2w)

2. $\frac{100 \times 5 \times 11}{(18)(2)}$

3. $\frac{6a \times 5b^2}{3a^3}$

4. $5\ \frac{(5y - 4y)}{10}$

5. 4d (6d) (0.25d)

6. $\frac{(2a - 3b)(3b)}{3cx}$

Name: ___________________________

Part F: Write the number of significant figures in the blank preceding the number.

1. __________ 23
2. __________ 1.498
3. __________ 248.3
4. __________ 107 cars
5. __________ 0.238
6. __________ 8.0335
7. __________ 0.05587
8. __________ 14.809
9. __________ 14.380
10. __________ 307
11. __________ 1.40082
12. __________ 0.00058900
13. __________ 4500
14. __________ 350,000
15. __________ 180.00
16. __________ 3.50

Part G: Compute the following. Use significant figures.

1. $(6.02 \times 10^{23})\ (8.65 \times 10^{4})$
2. $(6.02 \times 10^{23})\ (9.63 \times 10^{-2})$
3. $\dfrac{5.6 \times 10^{-18}}{8.9 \times 10^{8}}$
4. $(-4.12 \times 10^{-4})\ (7.33 \times 10^{12})$
5. $\dfrac{1.0 \times 10^{-12}}{4.2 \times 10^{-6}}$
6. $(-3.2 \times 10^{-5})\ (-8.6 \times 10^{-9})$
7. $\dfrac{(5.4 \times 10^{4})\ (2.2 \times 10^{7})}{4.5 \times 10^{5}}$
8. $\dfrac{(6.02 \times 10^{23})\ (-1.42 \times 10^{-15})}{6.54 \times 10^{-6}}$
9. $\dfrac{(6.02 \times 10^{23})\ (-5.11 \times 10^{-27})}{-8.23 \times 10^{5}}$
10. $\dfrac{(3.1 \times 10^{14})\ (4.4 \times 10^{-12})}{-6.6 \times 10^{-14}}$

Name: ___________________________

Part H

Below are some conversion factors used in the SI System, and which we will use in this class.

kilo- = 1000	**centi- = 1/100**	**milli- = 1/1000**	**Other**
Conversions			
1 kg = 1000 g		1000 mg = 1 g	1 mL = 1 cm^3
1 km = 1000 m	100 cm = 1 m	1000 mm = 1 m	1 L = 1 dm^3
		1000 mL = 1 L	1 cm = 10 mm

Solve each of the following problems. Show the correct set-up and always use units.

1. Determine the number of mm in 2400 m.

2. Determine the number of m in 6300 mm.

3. Determine the number of mm in 14.3 cm.

4. How many seconds are in 6.3 years?

5. Convert 3245 cm^3 to liters.

6. A metallurgist is making an alloy that consists of 543 g of chromium (Cr) and 4.5 kg of iron (Fe). Find the total mass of the mixture in kg.

7. How many mL of water (H_2O) will it take to fill a 2.0 L bottle that already contains 1.25 L of H_2O?

8. The density of lead (Pb) is 11.34 g/cm^3. Find the density of Pb in kg/dm^3.

Name: ________________________

Density Measurement

Purpose: Learn how to make density measurements.

Procedure:

Part A. Density of Deionized Water

1. Measure the mass of a 150 mL beaker on a balance.
2. In a 250 mL beaker, fill it about half full with deionized water.
3. Transfer about 9 mL of deionized water from the 250 mL beaker to a 10 mL graduated cylinder and record the actual volume.
4. Transfer all the deionized water from the 10 mL graduated cylinder to the measured 150 mL beaker, re-weigh, and record the total mass. This is your first trial.
5. Without discarding the deionized water from the 150 mL beaker, more deionized water will be added by repeating steps 3-4. This is your second trial.

Part B. Density of Unknown Liquid

1. Measure the mass of a 150 mL beaker on a balance.
2. Choose an unknown liquid and record its unknown number and/or letter, and transfer about 10 mL of the unknown liquid into a 50 mL graduated cylinder and record the actual volume.
3. Transfer all the unknown liquid from the 50 mL graduated cylinder to the measured 150 mL beaker, re-weigh, and record the total mass. This is your first trial.
4. Without discarding the unknown liquid from the 150 mL beaker, more of the same unknown liquid will be added by repeating steps 2-3. This is your second trial.
5. Discard the unknown liquid down the sink.

Part C. Density of Unknown Metal

1. Choose an unknown metal cylinder and record its unknown number and/or letter.
2. Measure the mass of the unknown metal cylinder on a balance.
3. In a 50 mL graduated cylinder, fill it about half full with deionized water and record its volume. This is the initial volume.
4. Slightly tilt the 50 mL graduated cylinder and slowly slide the unknown metal cylinder into the 50 mL graduated cylinder.
5. Record the new volume of deionized water in the 50 mL graduated cylinder. This is the final volume. This is also your first trial.
6. Using another unknown metal cylinder from the same unknown container, repeat steps 1-5 for your second trial.

Name: ______________________

Report:

Part A. Density of Deionized Water

	Trial 1	Trial 2
Mass of beaker	______________	______________
Mass of beaker + water	______________	______________
Mass of water	______________	______________
Volume of water	______________	______________
Density of water	______________	______________

Show calculation for the density of water:

Average density of water ______________

Was the density of water the same in the two trials? If not, what could have caused the difference?

Between the two trials, which density value is correct?

Name: ____________________________

Part B. Density of Unknown Liquid

Unknown number and/or letter	____________	
	Trial 1	Trial 2
Mass of beaker	____________	____________
Mass of beaker + unknown liquid	____________	____________
Mass of unknown liquid	____________	____________
Volume of unknown liquid	____________	____________
Density of unknown liquid	____________	____________

Show calculation for the density of unknown liquid:

Average density of unknown liquid ____________

Name: ______________________

Part C. Density of Unknown Metal Cylinder

Unknown number and/or letter ______________

	Trial 1	Trial 2
Mass of unknown metal cylinder	______________	______________
Initial volume of water	______________	______________
Final volume of water	______________	______________
Volume of unknown metal cylinder (by water displacement)	______________	______________
Density of unknown metal cylinder	______________	______________

Show calculation for the density of unknown metal cylinder:

Average density of unknown metal cylinder ______________

Identity of unknown metal cylinder ______________

Select from the following:

Aluminum, Density = 2.70 g/cm^3

Iron, Density = 7.87 g/cm^3

Copper, Density = 8.96 g/cm^3

From the experiment, was your unknown metal cylinder's average density value lower, higher, or the same as one of the given values? If not the same as the given values, explain what could have caused your density value to be lower or higher?

Name: ________________________

Chemical Reactions

Purpose: Perform qualitative observations of chemical changes.

Procedure:

1. **Reactions with oxygen:** Synthesis or combination reactions. Demonstration, in the fume hood, by the instructor.

    a. Metal + Oxygen → Metal oxide

        a. The metal used is magnesium.

Reactants	Products	Observations
Write the balanced chemical equation		

    b. Non-metal + oxygen non-metal oxide

        a. The non-metal used is sulfur

Reactants	Products	Observations
Write the balanced chemical equation		

Obtain a spot plate from the stock room. Check for cleanliness.
The different reagents for each set of reactions are in tub stations located either in the fume or along the perimeter of the laboratory. Do not change substances from one station to another.

Liquids and solutions are placed in flip top containers or bottles with droppers. Do not take off the top of the flip top containers, you can dispense dropwise each substance through the top (flipped).
Add few drops for each reaction (enough to see the changes)
For reactions with a solid and a liquid add, add a piece of the solid and enough liquid to cover it.

Perform each reaction in a different well of the plate.
When you finish, empty the reagents in the waste container located in the fume hood, wash and dry the plate before you return it to the stock room.

Name: ________________________

2. Single displacement reactions

a. Copper wire and silver nitrate solution.
b. Magnesium turnings and 0.1 M hydrochloric acid.
c. Copper wire and 0.1 M hydrochloric acid

a.

Reactants	Products	Observations
Write the balanced chemical equation		

b.

Reactants	Products	Observations
Write the balanced chemical equation		

c.

Reactants	Products	Observations
Write the balanced chemical equation, include phase labels		

Organize the elements tested in order of increased reactivity

3. **Double displacement reactions: Precipitations.**
The following are all aqueous solutions.

a. Silver nitrate and ammonium carbonate
b. Iron (III) chloride and sodium hydroxide
c. Copper (II) nitrate and sodium phosphate

a.

Reactants	Products	Observations
Write the balanced chemical equation, include phase labels.		

b.

Reactants	Products	Observations
Write the balanced chemical equation, include phase labels.		

c.

Reactants	Products	Observations
Write the balanced chemical equation, include phase labels.		

Name: ________________________

4. Double Displacement reactions: Acid base neutralizations.

Add exactly six drops of the acid to each of the reactions and a small drop of phenolphthalein indicator. Add sodium hydroxide base dropwise, with stirring, until you see the solution turns pink and the pink color stays. Report the drops of base required to neutralize each acid.

a. Nitric acid
b. Sulfuric acid
c. Phosphoric acid

a.

Reactants	Products	Drops required for neutralization
Write the balanced chemical equation, include phase labels.		

b.

Reactants	Products	Drops required for neutralization
Write the balanced chemical equation, include phase labels.		

c.

Reactants	Products	Drops required for neutralization
Write the balanced chemical equation, include phase labels.		
All the acid solutions have the same molar concentration. Why do they require different amounts of the base for neutralization?		

5. **Decomposition reactions.** Do these reactions in test tubes.
   a. Hydrate: Add a few crystals of copper (II) sulfate pentahydrate to a test tube. Hold the test tube with a test tube holder and use a Bunsen burner to heat the sample until you observe a color change.

Reactants and color	Products and color	Observations
Write the balanced chemical equation, include phase labels		
What is the liquid that condenses at the top of the test tube?		

Name: ________________________

b. Carbonate: Add a small amount of ammonium carbonate to a test tube. Heat the test tube holding a moist piece of litmus paper, with tongs, in the mouth of the test tube. Record the color of the litmus paper before and after the reaction.

Reactants	Products	Color change of the pH paper
Write the balanced chemical equation, include phase labels		
What substance caused the change in the litmus paper?		

6. **Exothermic and endothermic processes.** Place two test tubes in a test tube rack and add approximately three milliliters of water to each one.

a. Note the temperature of the water touching the test tube. Add the tip of the spatula of potassium chloride. Touch the test tube again to detect the temperature change.
There are arguments on whether dissolving ionic compounds in water is a chemical or a physical change. In this lab, we will treat it as a chemical change.

Reactants	Products	Exothermic or endothermic?
Write the balanced chemical equation including the heat term		

b. Note the temperature of the water touching the test tube. Add the tip of the spatula of calcium chloride anhydrous and touch the test tube again to detect the temperature change. Calcium chloride anhydrous is hazardous to the skin and eyes.

Reactants	Products	Exothermic or endothermic?
Write the balanced chemical equation, including the heat term		

Name: ________________________

7. Double displacement, gas forming reaction:

a. Add approximately two milliliters of aqueous sodium carbonate to a test tube. Hold the test tube, with a test tube holder, on top of the sink. Add hydrochloric acid, dropwise, until you observe evolution of gas.

Reactants	Products	Observations
Write the double displacement reaction and balance it		
Write the balanced chemical equation of the reaction that produces the gas observed		
Write the overall, balanced, reaction including phase labels		

Questions

1. Do all chemical reactions show, like the ones in this experiment, evidence of the change that can be detected with our senses?

2. What is an activity series?

3. Is the reaction in a cold pack exothermic or endothermic?

Name: ________________________

Compounds in Solution

Purpose: Study the property of ionic and molecular compounds

Procedure

1. Solubility of ionic compounds in water

Add approximately 4 milliliters of water to a test tube. Use its height to add the same amount of water to two other test tubes.

Add the tip of the spatula of each of the solids to different test tubes. Add more or less the same amount to each one. Mix the contents of the test tubes tapping the bottom of the test tub with the thumb. Observe if it is soluble, insoluble or slightly soluble. Save the samples for the conductivity test.

b. Ammonium chloride
c. Calcium sulfate
d. Calcium hydroxide

Formula of the compound	Cation and anion	Solubility in water
a)		
b)		
c)		

2. Polarity of molecular compounds

a. Solubility in water, a polar substance. Add approximately 4 milliliters of water to a test tube. Use its height to add the same amount of water to two other test tubes.

Add sugar, the tip of the spatula, to one of the test tubes. Mix and observe if it is soluble (polar) or insoluble (non-polar). Iodine reacts with metals, use a wooden splint to transfer few crystals to the water in the second test tube. Use a clip to make a hole in the vitamin E capsule and squish into the third test tube. Save the test tube(s) with solutions (dissolved substances) for the conductivity test.

a. Sucrose
b. Iodine
c. Vitamin E

Name: ___________________________

Compound	Formula	Polar or non-polar?
a)		
b)		
c)		
Water		

b. **Solubility in hexane, a non-polar substance**. Add approximately four milliliters of hexane to a test tube. Use its height to add the same amount of water to two other test tubes.

Add sugar, the tip of the spatula, to one of the test tubes and observe if it is soluble (non-polar) or insoluble (polar) in hexane. Iodine reacts with metals, use a wooden splint to transfer few crystals to the hexane in the second test tube. Use a clip to make a hole in the vitamin E capsule and squish into the third test tube.

a. Sucrose
b. Iodine
c. Vitamin E

Compound	Formula	Polar or non-polar?
a)		
b)		
c)		
Hexane		

3. Electrolyte solutions

Test the conductivity probe with the conductivity of deionized water.
Assess the conductivity of the solutions in part 1 experiment "Solubility of ionic compounds in water". Record relative brightness of the LED as +, ++ or +++.
Assess the conductivity of the sample(s) that dissolved in the experiment 2a "Solubility of molecular compounds in water"

Compound	Formula	Relative brightness. Electrolyte, weak electrolyte or non-electrolyte.
Deionized water		
Aqueous ammonium chloride		
Aqueous calcium sulfate		
Aqueous calcium hydroxide		
Soluble molecular compound		

Name: ________________________

4. Solubility of carbon dioxide in water as a function of temperature

Add approximately 40 ml of carbonated water and two drops of bromothymol blue indicator to a 250- milliliter beaker. Record the color of the solution. Bring to a boil on a hot plate, turn it off and observe the color change. Bromothymol blue is yellow in acid solutions and blue in neutral or basic solutions.

	Acidic or basic?
Color of solution before boiling	
Color of solution after boiling	
Write the equation for the reaction responsible for the acidity of the carbonated water	
What causes the change in acidity with increasing temperature?	

5. Solubility of potassium permanganate in water as a function of temperature.

Add approximately 25 milliliters of water to two 100-ml beaker. Heat it on a hot plate and turn it off just before boiling.
Add few crystals of potassium permanganate to each beaker and record the intensity of color at the times in the table as +, ++, +++ etc.

Time minutes	Permanganate dissolved in hot water	Permanganate dissolved in cold water
0		
5		
10		
What happens to the solubility of the permanganate in the cold water?		
What happens to the solubility of permanganate in the hot water?		

6. Precipitation of ions in solution.

Wash the spot plate from the previous experiment and add few drops of each of the ions in solution.

a) Add few drops of ammonium carbonate and record the appearance of a precipitate. If aprecipitate forms, write the net ionic equation.

Solution	Precipitate	NIE
$KCl_{(aq)}$		
$BaCl_{2(aq)}$		
$SrCl_{2(aq)}$		
$CaCl_{2(aq)}$		

Name: ________________________

Questions:

1. Are your results in parts 2a and 2b consistent? i.e. Do they provide the same results? Explain.

2. Are your results in parts 1 and 3 consistent? Explain.

3. In the flame test, different colors of light are emitted by different ions. What is the source of the light emitted?

Name: ________________________

Determination of a Reaction Yield

1. Obtain the masses, separately, of (2) 50 mL beakers.

2. Add between 0.75 and 1.00 g of the copper(II) chloride hydrate salt to each beaker.

3. Add enough 6M HCl to dissolve the solid. Each sample will require between 5-10 mL of acid. Do not add more than 10 mL of HCl to each beaker. Be sure to continually swirl the mixture.

4. Perform a mass-to-mass conversion and calculate how many grams of magnesium metal are required to react. Your instructor will guide you.

5. Multiply step 4 by 1.5. Obtain this new amount of magnesium twice. Do not combine the two batches.

6. Slowly add one batch of magnesium to one of the beakers containing your mixture. Repeat with the second mixture.

7. If there is any magnesium in the mixture that has not reacted, add an additional 1-2 mL of HCl.

8. When the reaction is done, decant (pour off) the liquid into a separate waste beaker.

9. Add 5 mL of deionized water to the copper residue, swirl, and decant into the waste beaker.

10. Dry the copper metal by placing its beaker on a hot plate.

11. Using thermal gloves, remove the beaker and set aside to cool. Determine the mass.

12. Discard all waste into the appropriate container.

Data	**Trial 1**	**Trial 2**
Mass of 50 mL beaker	____________	____________
Mass of copper salt	____________	____________
Stoichiometric mass of Mg	____________	____________
1.5 × stoichiometric mass of Mg	____________	____________
Mass of beaker containing dried copper residue	____________	____________

Name: ________________________

Questions/Calculations. Show your work.

1. Write the balanced chemical equation for today's reaction.

2. Which reactant was the limiting reagent? How do you know?

3. Based on your answer to question 2, determine the theoretical yield of copper for each trial.

4. Determine the actual yield of copper for each trial.

5. Determine the percent yield of copper. If two trials were performed, calculate the average percent yield.

6. If the copper was still wet when massed, how would this affect your percent yield? Explain.

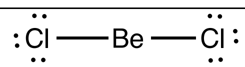
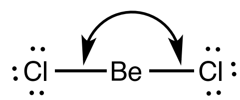
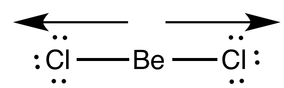
Name: ___________________________

The Shape of Molecules

Purpose: Determine polarity of molecules.

Check out a molecular model kit from the stock room. Check that the kit contains linear, trigonal planar, tetrahedral, trigonal bipyramidal and octahedral electron geometries.

1. Complete the following table and build the model for each. Show the model to the instructor.

Species **Valence electrons**	Lewis structure	Electron geometry Show angles	Molecular geometry Dipole moment (If any)
$BeCl_2$ **16**		180^0  Linear	Linear $\mu = 0$  non-polar
CO_2			
BCl_3			
NH_3			
H_2O			

Name: ___________________________

CH_4			
SF_4			
ICl_3			
PF_5			
SF_6			

Name: ________________________

Questions:

1. Write the Lewis structure for ammonium ion. Determine electron and molecular geometries

2. Write three resonance structures for the nitrate ion. Determine electron and molecular geometries.

3. What determines:

   a) the electron geometry and

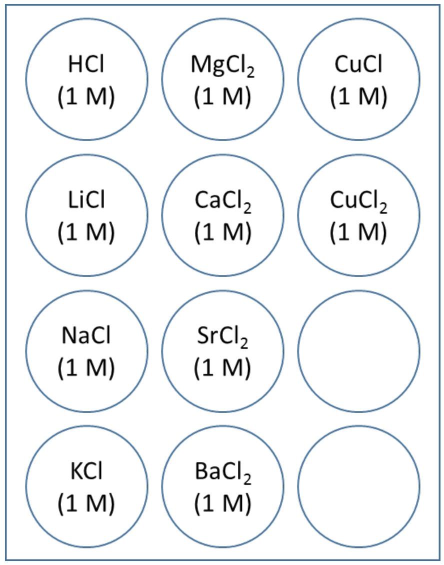
   b) the molecular geometry of molecules or ions?

Name: ________________________

Flame Test

Procedure:

1. Put on your approved safety goggles.
2. Add 10 drops of each 1 M solution to a different clean well in your well-plate:

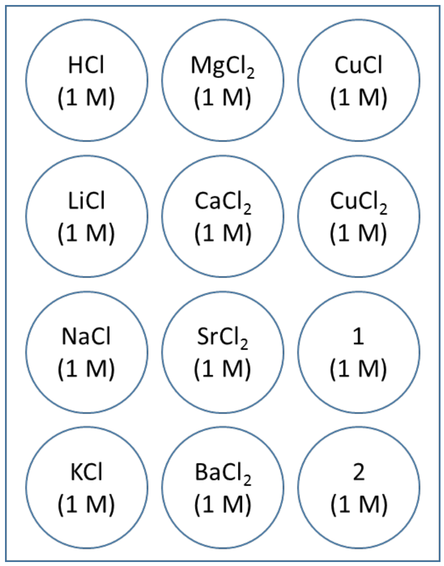


3. Set up a Bunsen burner with a blue flame (showing an inner blue cone):

4. Obtain either a platinum wire or a nichrome wire. Clean the looped end of the wire by dipping it into the 1 M HCl solution, remove and place the looped end of the wire into the hottest part of the Bunsen burner flame (the tip of the inner blue cone) until the only color observable is the blue color of the flame itself – this usually takes 3-5 seconds (no longer).
5. When the wire is clean, dip the looped end of the wire into the 1 M LiCl solution, remove and place the looped end of the wire into the hottest part of the Bunsen burner flame (the tip of the inner blue cone) for 3-5 seconds only. Observe and record (using colored pencils) any color produced during this 3-5 second period. Clean the looped end of the wire by dipping it into the 1 M HCl solution, remove and place the looped end of the wire into the hottest part of the Bunsen burner flame (the tip of the inner blue cone) until the only color observable is the blue color of the flame itself – this usually takes 3-5 seconds (no longer).

Name: ________________________

6. Repeat step 5 for each new chemical solution in the well-plate.
7. Obtain one or two unknown solutions (1, 2) from the lab instructor. Add 10 drops of each unknown 1 M solution to a different clean well in your well-plate:



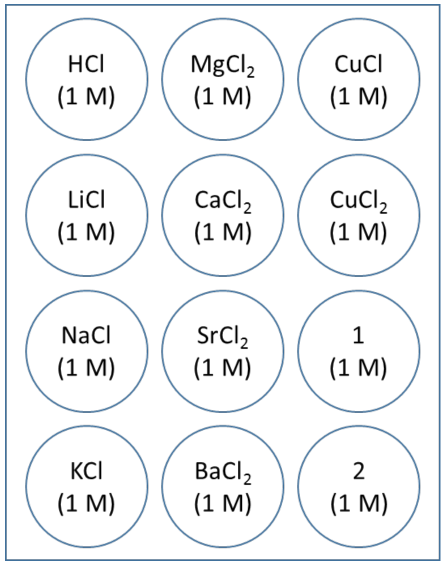
8. Repeat step 5 for each unknown solution. Unknown solution 1 and 2 will be the same chemical(s) used elsewhere in the well-plate. Identify the unknown solution(s) by comparing the flame color(s) to those already recorded earlier.
9. Repeat steps 4-8 using a hand-held spectroscope:

10. Use the spectroscope (which contains a diffraction grating) to observe the color of the flame for each of the solutions and unknown(s) in the well-plate. Use colored pencils to record the appearance of the flame for each solution as seen through the spectroscope.
11. Return all items used in this experiment and wash your work station and hands with soap and water. Finally, remove your safety goggles.

Name:

Results:

Use colored pencils to color in each well-plate below from steps 5-7.

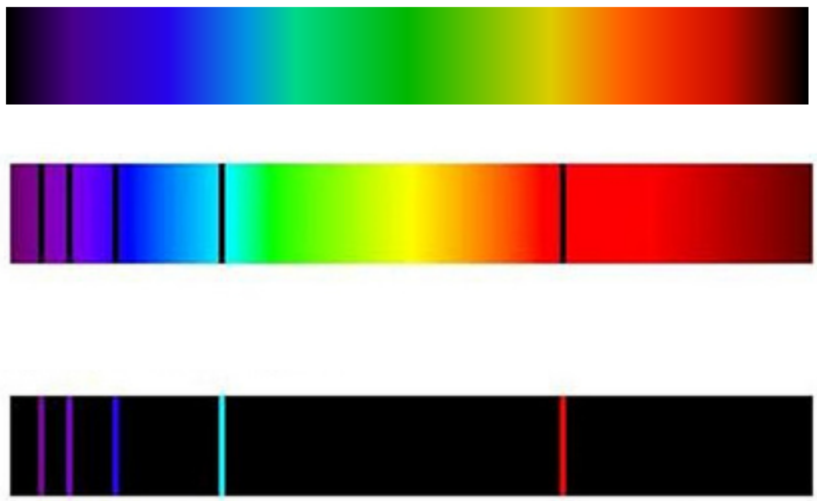


Use colored pencils to represent your observation for each well through the spectroscope from steps 8-10.

HCl	
LiCl	
NaCl	
KCl	
$MgCl_2$	
$CaCl_2$	
$SrCl_2$	
$BaCl_2$	
CuCl	
$CuCl_2$	
Unknown 1	
Unknown 2	
Unknown 1 =	
Unknown 2 =	

Name: ________________________

Discussion Questions:

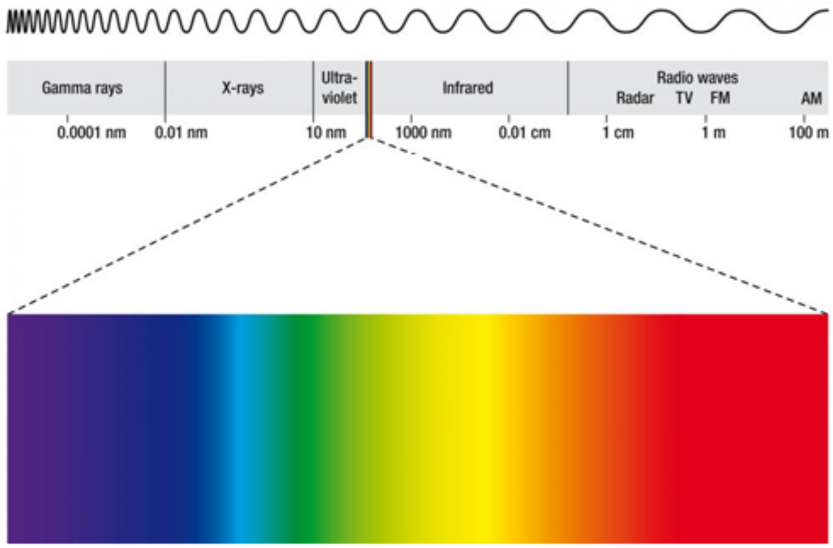


The following questions relate to the three spectra (plural of spectrum) shown above:

1. Which (if any) of the three spectra shown resemble the observations you made using your hand-held spectroscope?

2. How would you describe the three spectra shown? (Some online research may be required)

Name: ________________________



The following questions relate to the spectrum above:

3. How would you describe the relationship between the wavelength of visible light and its frequency?

4. How would you describe the appearance of the visible spectrum?

5. How would you describe the relationship between the color of visible light and its energy?

6. Suppose a wave of visible light of wavelength equal to 555 nm were traveling at a velocity of 55.5 cm/s past a point “A”. How long would it take for one wavelength of the light to travel past the point “A”?

Name: ___________________________

7. How would your answer to question 6 change (if at all) if the wavelength of the light was increased beyond 555 nm?

8. What is responsible for the observations made during this experiment?

Conclusions:

Identify the cause of the flame test observations made in this experiment and write a short conclusion based on your observations and from any ideas introduced in the "Discussion Questions" above (1 paragraph).

Future questions:

What questions does do you have now you've finished this experiment? (ask at least 1 question)

Name: ________________________

Charles' Law

Purpose: The purpose of this experiment is to experimentally verify Charles' Law.

Background: Jacques Charles was a French scientist who in 1787 observed that the volume of a gas is directly proportional to its absolute (Kelvin) temperature when the pressure and the number of moles of the gas are kept constant. Thus, the volume of a gas will increase when the temperature is increased and the volume of a gas will decrease with a decrease in temperature. Mathematically, this law can be expressed as :

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \qquad \textbf{Equation 1}$$

Where V_1 and V_2 are the initial and final volumes of the gas at temperatures T_1 and T_2 respectively. Please note that the temperature measurements have to be expressed in Kelvin. In this experiment, you will verify Charles' Law by measuring the volume of air at two different temperatures while maintaining a constant pressure. Then you will compare the volume measured with the calculated volume using Equation 1.

YouTube video: Click on the link below for the lab setup. This will give you an idea of how the lab is carried out.

https://www.youtube.com/watch?v=5M8GR6_zIps

Procedures

1. Checkout the rubber stopper and tubing assembly from the chemistry stockroom.
2. You also need a 125 mL Erlenmeyer flask, a 600 mL beaker (a 400 mL beaker will also work), hot plate (or Bunsen burner, ring stand and wire guaze), a plastic tray or pan and a utility clamp.
3. First, dry the 125 mL Erlenmeyer flask by heating it on a Bunsen flame. Make sure that there are no traces of moisture left in the flask.
4. Clamp the 125 mL flask to the beaker and add DI water to the beaker up to the neck of the flask. **(Figure 1)**
5. Heat the flask by boiling the water inside the beaker.
6. While the water is boiling, fill the plastic tray with enough cool water to cover and submerge the flask.
7. Measure the temperature of the boiling water and record it as $\mathbf{T_1}$ on your data table.
8. When the air in the flask has been heated for more than five minutes in the boiling water, crimp the rubber tubing with a tubing clamp, hold the flask with your utility clamp and immerse it in the tray of cool water.
9. Continue holding the flask under water and remove the tubing clamp from the rubber tubing. At this point water will enter the flask as it cools down. Keep the flask under water as the temperature of the flask equilibrates with the temperature of the cool water.
10. After five minutes, measure the temperature of water in the tray and record it on your data table as $\mathbf{T_2}$.

Name: ________________________

11. To make sure that the pressure of the flask is the same as the atmospheric pressure, raise or lower the flask until the water levels in the flask and in the tray are equal. This will ensure that the experiment is carried out at constant pressure.**(Figure 2)**
12. Now, close the tubing in the flask and take it out of the pan. Measure the volume of water in the flask using the 50 mL graduated cylinder. Record the volume of water on your data table as **V_{H2O}**.
13. To measure the initial volume of air in the flask **(V_1)**. Fill the entire flask with DI water up to the brim, insert the rubber stopper and tubing, then remove the stopper and tube, and measure the water in the flask using a 250 mL graduated cylinder.
14. Measure the barometric pressure in the laboratory and record it on the data table.
15. Refer to Table 1, look up the vapor pressure of water at T_2, and record it on your data table as **P water**.
16. Dry the flask thoroughly and repeat the procedure a second time.
17. To complete the data table refer to the calculations section.

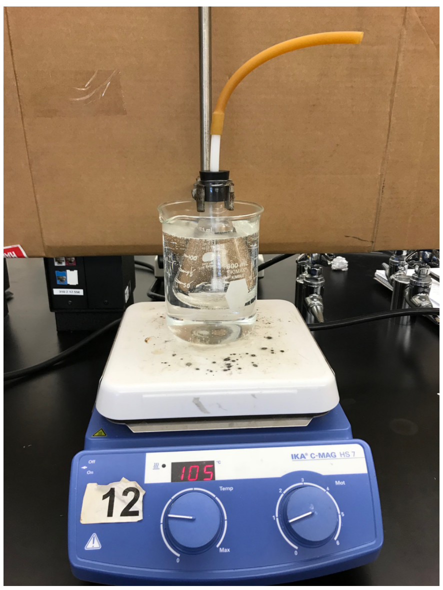


Figure 1. Heat flask in a boiling water bath.

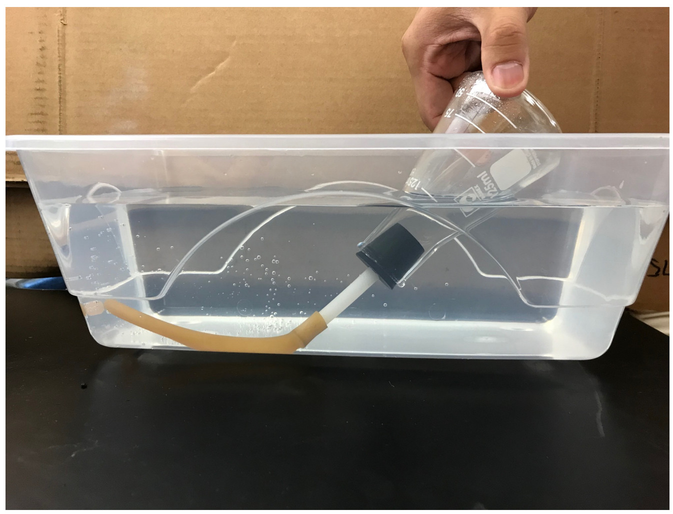


Figure 2. Adjust the water level in the flask to match the level in the bath.

Name: ________________________

Data Table:

	Trial 1	Trial 2
Temperature of boiling water **(T_1)**		
Temperature of air after cooling on the water bath **(T_2)**		
Initial volume of air in the flask at the temperature of boiling water **(V_1)**		
Volume of water drawn into the flask **(V_{H2O})**		
Volume of moist air **(V_2 wet)** drawn into the flask when cooling. **V_2 wet = V_1 - V_{H2O}**		
Volume of air collected at the cool temperature after the vapor pressure correction in Equation 2. **(V_2 measured)**		
Volume of air collected at the cool temperature calculated using Charles' Law **(V_2 calculated)**		
Atmospheric pressure in mmHg **(P_{total})**		
Water vapor pressure (in mmHg) at temperature T_2 **(P_{water})** (from Table I)		
Percent error between V_2 measured and V_2 calculated		

Table I. Vapor Pressure of Water as a Function of Temperature

Temperature (°C)	*Vapor Pressure (mm)*	*Temperature (°C)*	*Vapor Pressure (mm)*
10	9.2	20	17.5
11	9.8	21	18.6
12	10.5	22	19.8
13	11.2	23	21.1
14	12.0	24	22.4
15	12.8	25	23.8
16	13.6	26	25.2
17	14.5	27	26.7
18	15.5	28	28.3
19	16.5	29	30.0
		30	31.8

Name: ________________________

Calculations:

a. The air collected in the flask at the lower temperature also contains water vapor. So we refer to this volume as **V_2 wet**. We can calculate **V_2 wet** by subtracting the volume of water (**V_{H2O}**) drawn into the flask from the initial volume of air in the flask **V_1**.

b. In order for us to calculate the volume of air collected at the cool temperature (**V_2 measured)** , we have to use a vapor pressure correction. This correction is done using the Daltons Law of Partial Pressures. In Equation 2, we subtract the vapor pressure of water in the flask at the cooler temperature to calculate the experimental value of V_2 **(V_2 measured).**

$$V_2 \text{ measured} = V_2 \text{ wet } \times \frac{P_{\text{total}} - P_{\text{water}}}{P_{\text{total}}} \qquad \textbf{Equation 2}$$

c. Using Charles' Law calculate the theoretical value for V_2 **(V_2 calculated)** by substituting values for V1, T1 and T2 in equation 1. Show your work below.

d. Calculate the Percent error in between your experimental and theoretical value for V_2:

$$\%\text{ error} = \frac{|V_2 \text{ measured} - V_2 \text{ calculated}|}{V_2 \text{ calculated}} \times 100\%$$

Show your work for calculating % error:

Name: ________________________

Discussion questions:

1. Why do we need to clamp the rubber tube when we are transferring the flask from the boiling water to the cool water? Explain how this will affect your results.

2. If a balloon holds 3.7 L of gas at 25 ^{o}C, what will be the volume of the balloon at 46 ^{o}C? Assuming constant pressure. Show your work.

3. Discuss two sources of error in this experiment that might account for a high percentage error between V_2 measured and V_2 calculated.

Part A.

Standardization of approx. a 0.1M NaOH solution.

1. Measure about 0.720 g of KHP (Potassium hydrogen phthalate $KHC_8H_4O_4$) on a weighing paper
2. Transfer the measured KHP to a 250 ml Erlenmeyer flask.
3. Measure 50 ml of deionized water using a graduated cylinder and transfer the water to the flask containing the KHP.
4. Add three drops of Phenolphthalein indicator to the dissolved KHP.
5. Condition the burette by rising it with 5- 15 ml of NaOH solution. Discard this solution in the waste container.
6. Place the burette in the ring stand as shown in the figure below:

Fig 1. Burette on a ring stand.

7. Fill the burette with the NaOH solution making sure that there are no bubbles in the tip of the burette.
8. Record the initial volume of NaOH in the burette.
9. Place the Erlenmeyer flask under the burette (it is recommended to place a piece of white paper under the Erlenmeyer flask. (See picture below).

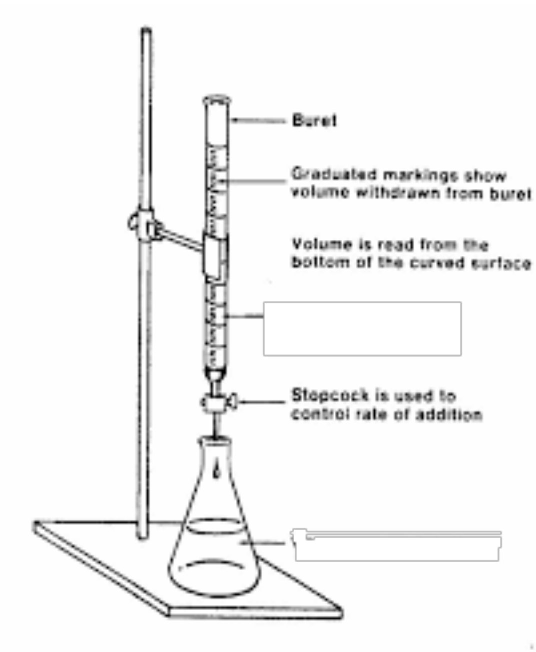


Figure 2. Set up for titration.

10. Titrate the KHP solution until the equivalence point is reached.
11 Record the volume of NaOH added to reach the equivalence point.
12. Repeat the titration two more times, for a total of 3.
13. Before proceeding to the second part of the experiment compute the average molarity of the NaOH solution and show the calculations to your instructor.

Part 2. Concentration of acetic acid in vinegar.

1. Transfer 4 – 5 ml of vinegar form the burette in the chemical hood to
a 125 ml Erlenmeyer flask and dilute to a total volume of 50 ml with deionized water.
2. Add 3 drops of phenolphthalein indicator.
3. Re-filled the burette with the standardized NaOH solution. Record the initial volume.
4. Titrate the vinegar, with the NaOH solution, to the equivalence point.
5. Repeat the process for a total of three times.
6. Compute the average molarity of the Acetic Acid in the vinegar sample.

Data and results.
Standardization of NaOH.

Data	Trial 1	Trial 2	Trial 3
Mass of KHP			
Initial volume of NaOH			
Final volume of NaOH			
Volume of NaOH added to equivalence point			
Molarity of NaOH			
Average molarity			

Calculations:

Dada and results.
Titration of Vinegar.

Data and results	Trial 1	Trial 2	Trial 3
Initial volume of NaOH			
Final volume of NaOH			
Volume of NaOH added to the equivalence point			
Molarity of acetic acid in vinegar			
Average Molarity			

Calculations.

Name______________________________ Date________ Instructor__________________

Organic Compounds and Isomers

Data:

A. Structure of Alkanes

	Complete structural formula	Condensed structural formula
Methane		
Ethane		
Propane		

B. Constitutional Isomers

	Complete structural formula	Condensed structural formula
Butane		
Isomer	Name:	

	Complete structural formula	Condensed structural formula
Pentane		
Draw and Name All Isomers of C_5H_{12}		

	Complete structural formula	Condensed structural formula
Hexane		
Draw and Name All Isomers of C_6H_{14}		

C. Cycloalkanes

	Complete structural formula	Condensed structural formula
Three Carbon Atoms	Name:	
Four Carbon Atoms	Name:	
Five Carbon Atoms	Name:	

Questions:

1. Draw complete structural formula of 2-Bromo-3,4-dimethyloctane.

2. Consider molecular formula $C_3H_6Br_2$. Draw complete, condensed structural formulas of each isomer of $C_3H_6Br_2$. Provide IUPAC name of each molecule you have drawn.

3. Write the condensed structural formulas and name for all the constitutional isomers with the formula C_4H_9Br.

4. Write the condensed structural formulas and name for all the constitutional isomers with the formula C_7H_{16}.

Name: ______________________

<u>Enzyme Specificity</u>

Are Sucr*<u>ase</u>* and Lact*<u>ase</u>* specific to Sucr*<u>ose</u>* and Lact*<u>ose</u>*?

<u>I: Experimental Procedure</u>

1. Add 0.3 g of sucr**ose** to three different test tubes. Make sure to remember to label them 1 to 3.

2. Add 5 mL of DI water to test tube number 1. Add 5 mL of sucr**ase** to test tube 2. Add 5 mL of lact**ase** to test tube 3.

3. Add 0.3 g of lact**ose** to three different test tubes. Make sure to remember to label them 4 to 6.

4. Add 5 mL of DI water to test tube number 4. Add 5 mL of sucr**ase** to test tube 5. Add 5 mL of lact**ase** to test tube 6.

5. Place all six test tubes in a hot water bath at 35-40 ^{o}C for 30 minutes, approximately mimicking the temperature of your body. You can make a water bath by taking a large 400-600 mL beaker and fill it up to about ¾ full with tap water. Then place the beaker on a hot plate and begin heating.

6. While your test tube samples are incubating in the hot water bath, take "pea size" sample of glucose and mix it with 1 mL of water in an additional test tube. This step is going to allow you to witness a positive test for glucose. After mixing the glucose and water, take a glucose test strip and dip it in the glucose solution and wait 1 minute. Take the glucose test strip out and wait a couple of minutes for the test result to develop. Once you witness the color change of the test strip, note the color and concentration and record the results in part II.

Name: ___________________________

7. Once the incubation of test tubes 1 through 6 is complete, turn off the hot plate and allow the water bath to reach room temperature. Place a glucose test strip in each of the 6 test tubes. Making sure to use a pencil to label each test strip 1 to 6 so that you can keep track of the different test strips for each test tube. After placing the test strips in each test tube, wait 1 minute, then take them out as before and allow a couple of minutes for the test to develop and come to completion. Note the color and concentration of each test strip, and record in part B.

II: Data

Test Tube	**Result (color)**	**Concentration (**μg/dL)
Glucose Positive Test		
1 (sucrose+water)		
2 (sucrose+sucrase)		
3 (sucrose+lactase)		
4(lactose+water)		
5(lactose+sucrase)		
6(lactose+lactase)		

Name: ______________________________

III: Questions

1) When sucrose and lactose hydrolyze, what are the products of these reactions?

2) What result indicates that sucrose and lactase of gone through hydrolysis?

3) Under which conditions did you see hydrolysis of sucrose?

4) Under which conditions did you see hydrolysis of lactose?

5) Are enzymes specific? Explain your answer.

6) The units for the concentration of the glucose are μg/dL, convert these units into molarity units, mol/L.

Name: ________________________

Hydrolysis of Sucrose

Purpose: The purpose of this experiment is to hydrolyze sucrose into its monosaccharides and confirm the hydrolysis by Benedict's test.

Background:
Sucrose is a disaccharide composed of fructose and glucose. The bond between fructose and glucose is an α (1,2)-glycosidic linkage. Since both the anomeric carbons of glucose and fructose are capped due to the glycosidic linkage, sucrose gives a negative result when tested with Benedict's solution. Hydrolysis of sucrose converts it back to fructose and glucose. These being reducing sugars will yield a positive test to Benedict's solution. In this experiment we will carry out the hydrolysis of sucrose by two methods. One using HCl solution, and the other using the enzyme sucrase. A positive test to Bendict's solution confirms that the hydrolysis is successful.

Benedict's test: Benedict's reagent is a mixture of copper (II) sulfate, sodium carbonate and sodium citrate. A reducing agent will convert the Cu^{2+} in Benedict's solution to a Cu_2O precipitate and the color of the solution changes from blue to orange-red. In some cases, reducing sugars also produce a red, green or yellow precipitate, all of which are considered as positive reactions to Benedict's solution.

Procedures

1. Wash five small test tubes with soap and deionized water and set them on a test tube rack.
2. Label the test tubes 1 to 5.
3. In test tubes 1, 2 and 3 add about 0.3 g of sucrose.
4. Add 5 mL deionized water to test tube #1. Add 5 mL of 1M HCl solution to test tube #2, and finally add 5 mL of aq. sucrase to test tube # 3.
5. Prepare a 250 mL beaker filled with deionized water heated to 37 ^oC.
6. Incubate these three test tubes for about 30 min on the 37 ^oC water bath. You may shake the test tubes periodically. Check the temperature frequently and add some warm water to keep the temperature constant.
7. Now, while the three test tubes are incubating, prepare test tube # 4 with 0.3 g of sucrose and 5 mL water. In test tube # 5 add 0.3 g of glucose and 5 mL water.
8. After the incubation is complete, neutralize the acid in test tube # 2 with 1 mL of 3 M NaOH. You will need to check the pH of the solution using pH paper to confirm that the solution is no longer acidic.
9. Perform the Benedict's test on all five solutions by adding 5 mL of Benedict's reagent into each test tube and heating them on a hot water bath for about 5 mins.
10. Record your observations on your data table

Name: ________________________

Data Table:

Test tube # (sample)	**Benedict's test observations**	**Positive/ negative**
1 (control)		
2 (sucrose + HCl)		
3 (sucrose + sucrase)		
4 (sucrose)		
5 (glucose)		

Discussion questions:

1. Which test tube gave a positive test to Benedict's reagent? Explain.

2. Which test tube gave a negative test to Benedict's reagent? Why?

3. Did you see the hydrolysis of sucrose under both conditions? Mention any noticeable differences in your observations.

4. Lactose is another disaccharide which contains glucose and galactose. But it gives a positive test to Benedict's reagent without the need for hydrolysis. Explain why this is so.

Name: ________________________ Row: _______

Date:_____________ Period:______

Lipid Worksheet

Lipids are fats including oils, waxes, steroids and cholesterol. Lipids are made from a hydrocarbon monomer that links together to form a hydrocarbon chain.

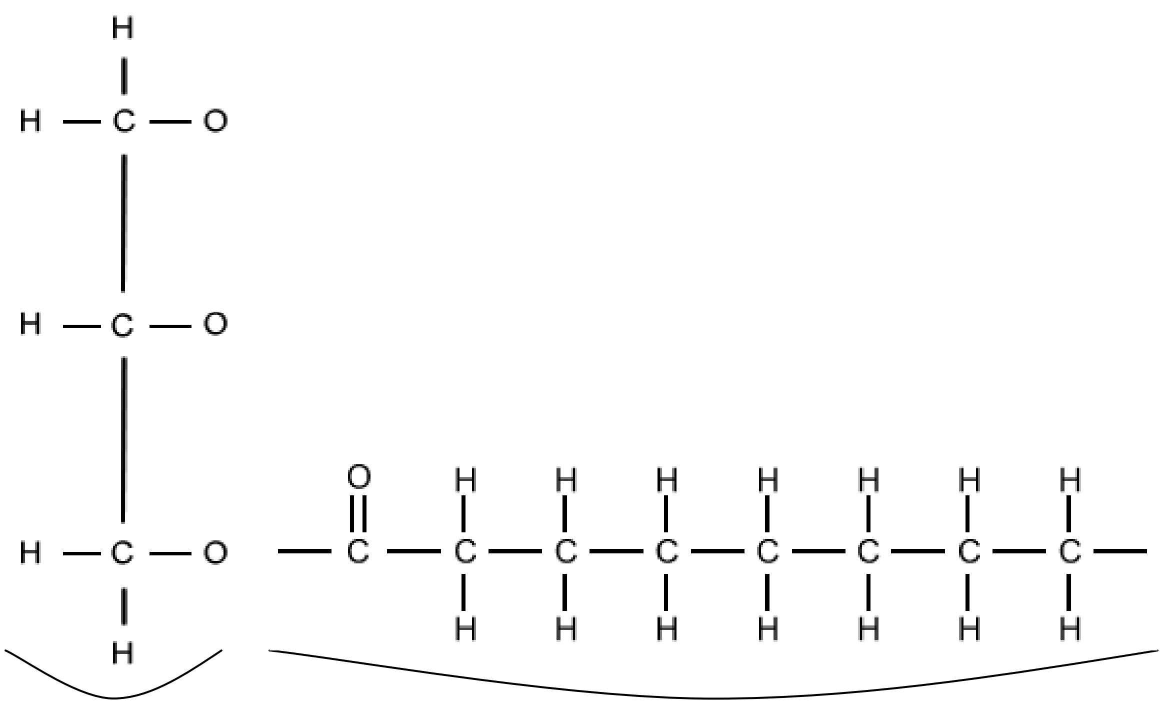
Hydrocarbon

Hydrocarbon Chain

Hydrocarbon chains vary in length and are nonpolar. Nonpolar molecules are hydrophobic, meaning they do not interact or mix with water. The three most common forms of lipids in the human body are triglycerides, phospholipids and cholesterol. Most of the fats you consume are triglycerides. Your body breaks them down and then stores the fats as new triglycerides.

Triglycerides are three fatty acids bonded to a glycerol. Fatty acids are a hydrocarbon chain with a carboxyl group connecting it to the glycerol. Glycerol is a three carbon alcohol. There are two types of fatty acids, saturated and unsaturated. Saturated fatty acids are straight and are found mostly in animals. Unsaturated fatty acids are bent because of a double bond and are found mostly in plants.

1) Looking at the fatty acid below, copy it into the two remaining rows.



Glycerol

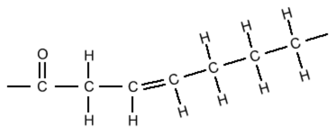
Fatty Acid

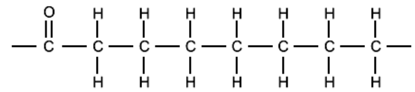
2) Fatty acids are composed of a carboxyl group and ____________________________.

3) What are the four parts of a triglyceride? _____________ & 3 __________________

4) The human body stores fats as __________________________.

5) Label the following fatty acids as saturated or unsaturated.

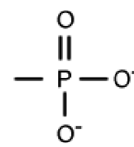




_____________________ _____________________

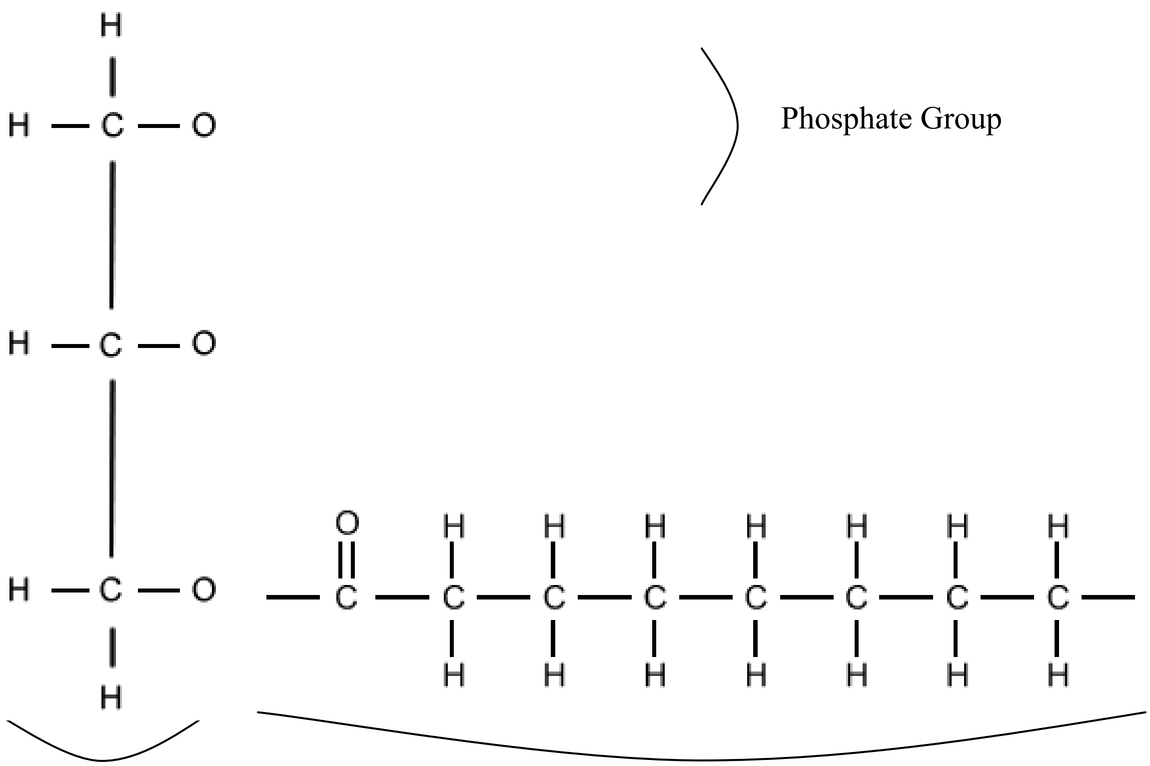
6) When a hydrocarbon chain is bent, it is called ________________________________.

Phospholipids are similar to triglycerides except that a phosphate group replaces one of the fatty acids. The phosphate group is a polar molecule. Polar molecules are hydrophilic and interact with water.

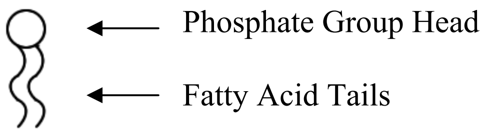


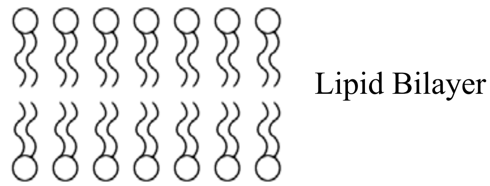
Phosphate Group

7) Fill in one phosphate group and the remaining fatty acid. Label all the parts.

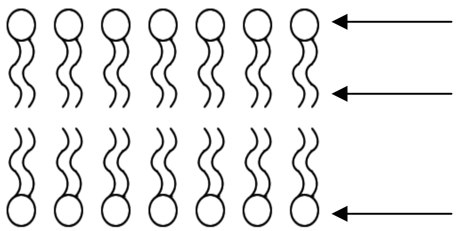


The common form of a phospholipid looks like a circle with two tails. Phospholipids are polar on the phosphate group side and nonpolar on the fatty acid side. When one phospholipid is next to another phospholipid, they line up with the heads on one side and the tails on the other side. Two rows of phospholipids are called a lipid bilayer and they make up the membranes of all cells.





8) Below, label which parts are polar and nonpolar.



9) Where would you find the lipid bilayer in a cell? ______________________________

Cholesterol has a different shape in that it forms rings instead of hydrocarbon chains. Cholesterol is found only in animals in: body tissues, cell membranes and blood. All steroid hormones (testosterone, estrogen, and progesterone) are derived from cholesterol.

10) What lipid do animal cells have inside their cell membranes? __________________

11) What does hydrophobic mean? ____

12) What are steroid hormones made from? ____________________________________

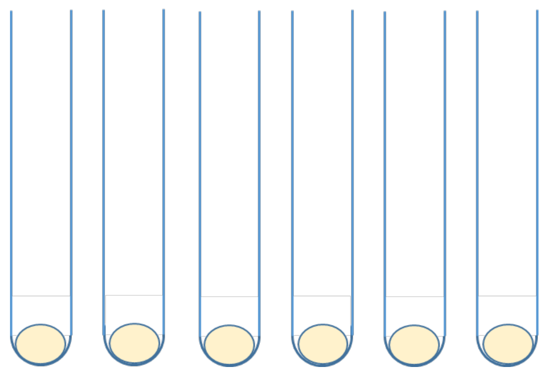
Name: ________________________

Protein

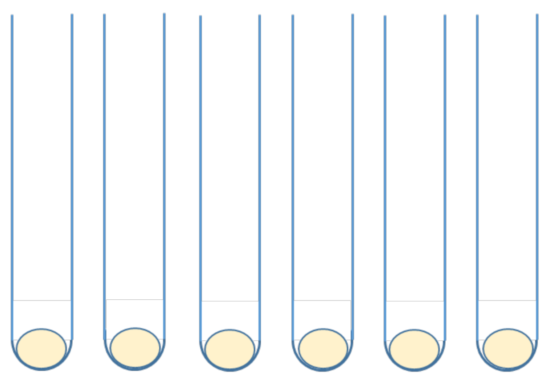
Procedure:

Part A

1. Put on your approved safety goggles.
2. Add enough egg-white to cover the bottom of a test tube (the exact amount does not matter).
3. Repeat step 2 for 5 other test tubes. You should now have egg-white in 6 separate test tubes:



4. The egg-white in each test tube will be subjected to a unique stress, including temperature and chemical stresses. Label each test tube as shown below:



Control | Low Temp (4 °C) | High Temp (60 °C) | CH_3CO_2H (1 M) | HCl (1 M) | NaOH (1 M)

5. Do not add anything to the test tube labeled "Control".
6. Do not add anything to the test tubes labeled "Low Temp" or "High Temp". Instead, submerge the bottom half of the test tube labeled "Low Temp" in an ice-bath (your instructor will show you how to set up an ice-bath). Submerge the bottom half of the test tube labeled "High Temp" in a beaker of water set to approximately 60 °C. A hot plate and a thermometer should be used to maintain and monitor the beaker of water at 60 °C.
7. Add 10 drops of each 1 M solution to the test tubes labeled CH_3CO_2H, HCl, and NaOH, respectively.

Name: ___________________________

Results:

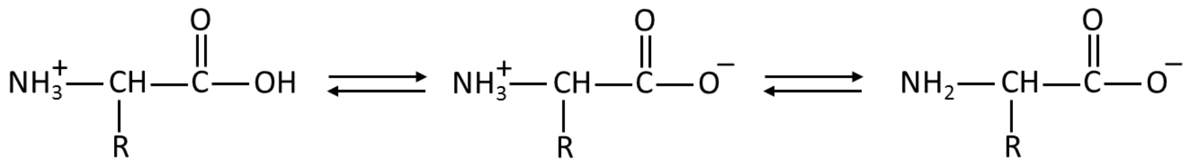
Part A

Monitor the physical appearance of each test tube during a period of 10 min and record your observations below. Leave the test tubes for another 30 min then record your final observations.

Time (min)	Observation					
	Control	Low Temp	High Temp	CH_3CO_2H	HCl	NaOH
0						
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
40						

Name: ____________________________

Discussion Questions:
Part A



1 2 3

The following questions relate to the 3 structures representing a general α-amino acid at different pH conditions (above):

1. In a solution at low pH, which structure (1, 2, or 3) would be adopted by a general α-amino acid? Justify your answer.

2. For the reaction from 1 to 2, does the α-amino acid behave as an acid or a base? Justify your answer.

3. For the reactions from 3 to 2 to 1, does the α-amino acid behave as an acid or a base? Justify your answer.

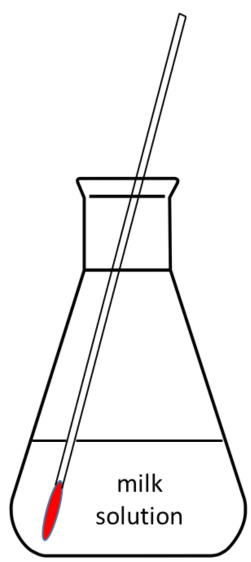
4. What is the "isoelectric point", and does the isoelectric point influence whether a general α-amino acid adopts structure 1, 2, or 3? Explain your answer.

5. What is responsible for the observations made during this experiment on the egg-whites?

Name: ________________________

Conclusions:
Part A
Write a short conclusion to explain your observations and incorporate any ideas introduced in the "Discussion Questions" above (1 paragraph).

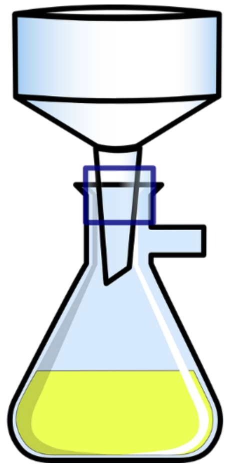
Procedure
Part B
1. Put on your approved safety goggles.
2. Weigh out approximately 3 grams of powdered milk into a 125 mL Erlenmeyer flask and add 10 mL of deionized water.
3. Place the Erlenmeyer flask on a hot plate and heat the powdered milk solution to approximately 45 ^{o}C (do not exceed 55 ^{o}C):



4. Having brought the temperature of the milk solution to approximately 45 ^{o}C add to it (dropwise) acetic acid. Record any observations occurring. Use a glass stir rod to gently stir the mixture. Keep adding (dropwise) acetic acid until you no longer observe any changes.

Name: ________________________

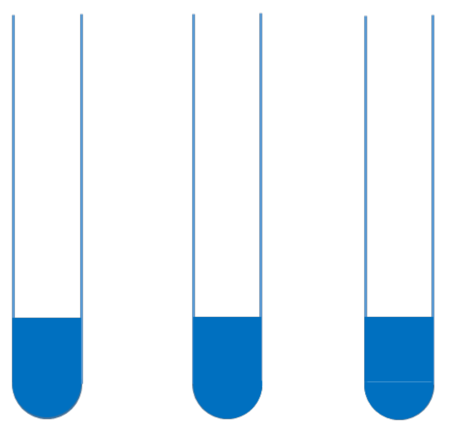
5. Use a vacuum filtration apparatus to filter separate any solids (precipitate) from liquids (supernatant). Your instructor will demonstrate this technique:



6. Research what the precipitate is, record its appearance and then discard as per your instructor's instructions. Retain the supernatant for the lactose and protein tests.
7. Add 100 mL of regular tap water to a 400 mL beaker and heat on a hot plate to approximately 60 ^{o}C.

Lactose Test:

8. Add 3 mL of Benedict's reagent to each of 3 test tubes:

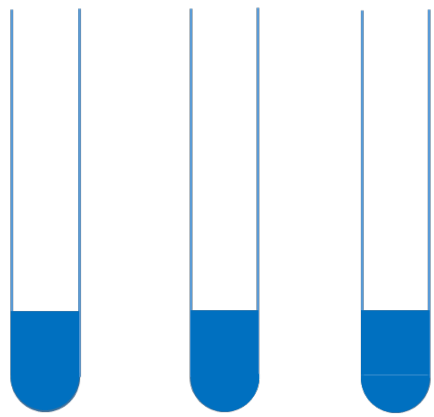


9. Add 1 mL of deionized water to the test-tube labeled "Control".
10. To the other two test-tubes add 0.1 g of lactose and 1 mL of the supernatant liquid (from step 5), respectively.
11. Place all 3 test-tubes in the heated water bath and heat at approximately 60 ^{o}C for 5 min.
12. Observe and record any changes occurring during the 5 min heating period.

Name: ___________________________

Protein Test:

13. Add 1 mL of Bradford's reagent to each of 3 test tubes:



14. Add 1 mL of deionized water to the test-tube labeled "Control".
15. Add 10 drops of bovine serum albumin (BSA) and 1 mL of the supernatant liquid (from step 5) to the remaining two test-tubes, respectively.
16. Allow these three test-tubes to sit at room temperature for 5 min.
17. Observe and record any changes occurring during this 5 min period.

Results

Part B

Observations following addition of acetic acid to milk solution:			
Time (min)	**Observation (Lactose Test)**		
	Control	**Lactose**	**Supernatant**
0			
1			
2			
3			
4			
5			

Name: ___________________________

	Observation (Protein Test)		
0	**Control**	**BSA**	**Supernatant**
1			
2			
3			
4			
5			

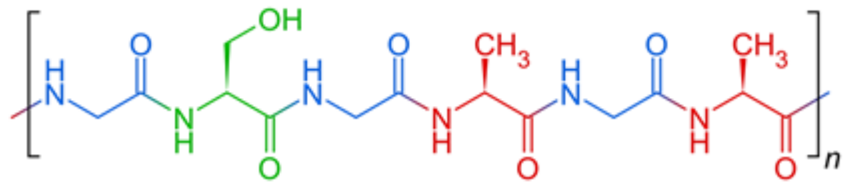
Discussion Questions:

Part B

1. What do Benedict's and Bradford's reagents test for, respectively?

2. How do Benedict's and Bradford's reagents work? Show chemical reactions for each test and expected observations during operation.

Name: ___________________________



The following questions relate to the above structure:

3. What structure is represented?

4. What is the identity of each colored component?

5. What kinds of bonding are present?

6. What kinds of bonding are possible?

7. Rank the kinds of bonding given in your answer to question 4 above in order from strongest to weakest.

Name: __________________________

Conclusions:

Part B

Write a short conclusion to explain your observations and incorporate any ideas introduced in the "Discussion Questions" above (1 paragraph).

Future questions:

What questions do you have now that you've finished this experiment? (ask at least 1 question about Part A and at least 1 question about Part B)