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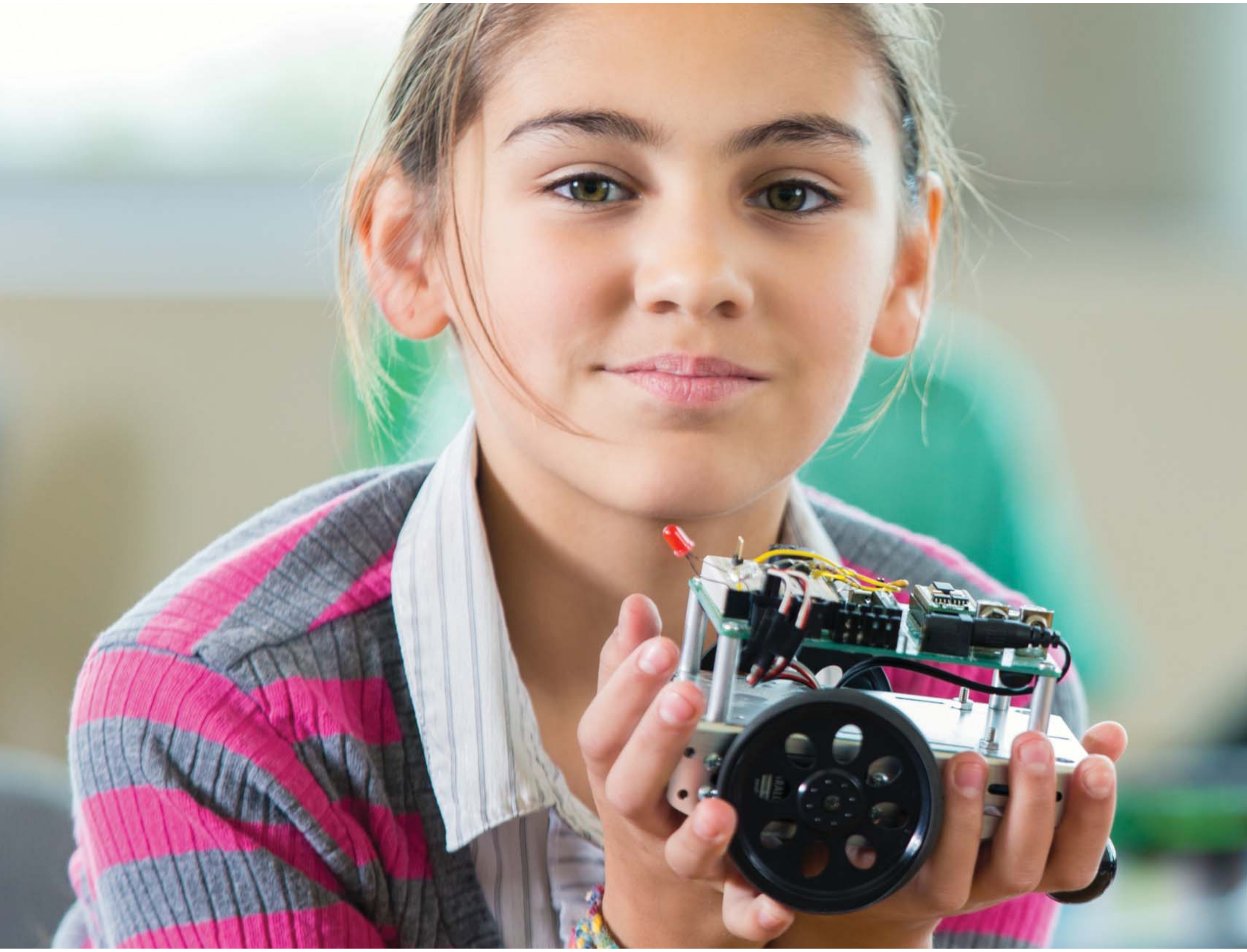

idea packet

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The Chemistry of Ocean Acidification

The Chemistry of Ocean Acidification

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Goals and Objectives

As a teacher I frame my classes around the idea that chemistry is not a singular subject, but explains that nature of the world around us. Throughout the year I introduce students to environmental concepts that they would not necessarily be aware of and the science behind them.

Acids and Bases is a culmination unit in a Pre-AP Honors or Gifted Chemistry course, though it could be modified to fit into a variety of courses. At the end of the year, students have been taught a host of concepts that will recalled from solutions to ions to particulate modelling. My course is math heavy requiring understanding of formulas and calculations. Instead of looking at acids and bases as determining the pH of samples from around the lab, students shift their focus to a global crisis – ocean acidification. They will learn about buffers or why seawater is different from tap water, the ocean as a carbon dioxide sink and we are causing a decrease in the pH, and the affects that this has on the world's ecosystems. As a final inquiry experiment the students develop a multi-day research experiment involving seawater and pH. The direction and details of their experiment are at their discretion.

By the end of lab students should have a firm understanding of the macroscopic and microscopic scale view of ocean acidification and the role in which they play. They should be able to calculate concentrations and explain Le Chattelier's Principle, but also describe their carbon footprint and why the coral reefs of the world are at risk due to ocean acidification. Miami has a National Park only a few miles from downtown. The residents of this city should understand the scientific impact they have on it.

This lab should not be intimidating by the depth of chemistry that is in it. The topics could be altered and used in almost any course. Through the use of demos, phenophalthalein or lab quest any of this could be understood by even an elementary school student. All of the materials other than a few chemicals were picked up by myself or a student at the beach, so everything is very accessible to even the most limited of schools.

Many different Florida state standards are covered in the duration of the unit. The most obvious are which are chemistry strands involving reactions and acidity. Students will become more versed in using logarithms and manipulating algebraic equations. They will apply this knowledge to understand the human impact on the environment and how to make better decisions on the local and state levels. Finally, depending on the intensity of the lab write up, students will analyze real data from NOAA to see how greenhouse gas emissions affect and then use that to design and experiment.

Florida Standards

SC.912.P.8.11 - Relate acidity and basicity to hydronium and hydroxyl ion concentration and pH.

SC.912.P.8.8 - Characterize types of chemical reactions, for example: redox, acid-base, synthesis, and single and double replacement reactions.

SC.912.P.8.9 - Apply the mole concept and the law of conservation of mass to calculate quantities of chemicals participating in reactions.

SC.912.N.4.1 - Explain how scientific knowledge and reasoning provide an empirically-based perspective to inform society's decision making.

SC.912.N.4.2 - Weigh the merits of alternative strategies for solving a specific societal problem by comparing a number of different costs and benefits, such as human, economic, and environmental.

MAFS.912.N-Q.1 - Cluster 1: Reason quantitatively and use units to solve problems.

LAFS.910.RI: Reading Standards for Informational Text

LAFS.910.RST: Reading Standards for Literacy in Science and Technical Subjects 6-12

Unit Overview

Each day is completed in block scheduling of 90 minute periods.

Day 1: pH

Introduce pH as a concept of measuring the concentration of hydronium ions. Take measurements of various household objects to determine their acidity and design a pH scale. Begin pH calculations.

Day 2: Acids and Bases

Differentiate between Arrhenius, Bronsted-Lowry and Lewis Acid and Bases. Design a poster on a common acid or base and its use in life.

Day 2: Buffer Systems

Le Chattelier's Principle - Explain why seawater resists changes in acidity or basicity to an extent. Use sand to show how seawater is given this property.

Day 3: Ocean Acidification

Carbon Dioxide is introduced as a greenhouse gas and how this affects the pH of the ocean. Show how coral reefs are affected. Students begin to develop a multi-day lab to monitor some aspect of pH and seawater.

Day 5 and on: Lab Days

The lab is incorporated throughout the next two weeks and students are given an hour on the first day to set up their experiment or discuss design procedures with the instructor. During the following days, more practice in acid/base calculations will be given 10-20 minutes to record data as necessary.

Day 1: pH

Students are introduced the concept of pH as a measure of hydrogen ion concentration. Students should have some idea on how to calculate solutions. I began with the Alka-Seltzer Rainbow Demonstration (Chem-Fax!). They will see how the beaker changes colors depending on the pH and will set up for the next lesson on buffers.

Five to ten every day liquids are provided such as lemon juice, soda, vinegar, orange juice, distilled water, antacid, seawater, etc. Students will use a well-plate to determine the pH using phenopthalein and begin to create their own pH scale. I will draw on this and show them how to calculate hydrogen ion concentration based off of this number.

I like to ask where water should be on this scale before we begin and where they think seawater will be. This leads to a discussion on water being amphoteric and how it can act as an acid or a base. Students often think that a higher pH means more acidic, when it actually means there is a lower concentration of hydrogen ions. It can also mean that there is a greater concentration of hydroxide ions.

Home Learning: pH calculations (Appendix A)

Day 2: Acids and Bases

More practice is given in calculating hydrogen/hydroxide ion concentration and pH/pOH.

Introduce students to the three definitions: Brønsted–Lowry, Arrhenius and Lewis. The majority of the focus will be on Brønsted–Lowry. Have students determine an acid/conjugate base and base/conjugate acid pairs in groups.

Nomenclature should be stressed so students are able to properly express what species they are referring to. I work on this extensively throughout the year. This is a great time to bring about a mini-project. Have a list of often used acids and bases in industry and have the student research the name, pH, relative strength (very strong, slightly weak, etc), and specific uses of the chemical. All of the information found should be cited neatly and presented on a small poster with a picture of something related to the acid or base.

Home learning: Nomenclature (Appendix B) and finish project

Day 3: Buffers

Begin class with a demonstration of measuring the pH of distilled water and seawater before and after sand is added. Explain how calcium carbonate is a buffer and the basic principles of Le Chattelier's Principle.

Have students complete a mini-lab with two beakers, one with distilled water and the other with seawater. Record change in pH as increments of five drops of a strong acid and base are added. Indicator solution or pH meters can be used.

Introduce alkalinity and explain that seawater carbon chemistry. Molecular model kits are used to create seawater buffering reactions.

Finally, this is extended into the "Need to Breathe" Activity. Have students hold their breath as long as possible. Our blood acts as a buffer in the same way that the seawater does. Breathing helps keep our blood an optimal pH. With a carbon dioxide build up, pH decreases.

Home Learning: Finish Poster

Day 4: Ocean Acidification

Now that there is a basic understanding of pH and buffers, students can begin to see how everything is connected to make a healthy ecosystem. Begin by showing the “NOAA – The Other CO_2 Problem” (youtube.com) and “Ocean Temperatures – Changing Planet” (youtube.com). I then have students complete a carbon footprint calculator (i2sea.stanford.edu/calculate) to see their own impact on the environment.

Ocean Acidification main impact is on coral bleaching. A connection should be made between the further acidifying of our oceans and what ramifications that has on the environment and on the students themselves. This day is mostly about discussion and leads into the introduction of the multi-day research lab.

I gave my student free reign to design as they wished. It only needed to involve pH and seawater. The first day is the formation of groups and initial research. Students have wanted to see a connection between temperature, the introduction of various flora and fauna and the dissolution of shells and other materials. It is graded off of my formal lab report rubric (Appendix C)

Day 5: Ocean Acidification part 2

Class is started by going out and observing car exhaust being piped into a gallon with water and indicator solution. This leads to a discussion of sources and sinks of carbon dioxide in the carbon cycle and ways to mitigate the release of CO_2.

Students are able to see their own microscale version of this by using a straw and blowing into two different beakers, one containing distilled water and the other seawater.

The lab is set up or further developed. I gave students the opportunity to work on it for 10-20 minutes a day for data collection or come in before or after school. This unit was run at the end of the year during testing, which is perfect for multiple lab days.

Resource List

"Alka-Seltzer® Rainbow." *Chem-Fax!* 10456 (2009): n. pag. Flinn Scientific, Inc. Web. 15 Mar. 2014.

"Carbon Footprint Calculator." *Calculate My Footprint*. I2SEA, 2016. Web. 09 Aug. 2016.

GlobalClimateNews. "NOAA Ocean Acidification - The Other Carbon Dioxide Problem." *YouTube*. NOAA, 02 Jan. 2012. Web. 09 Apr. 2014.

Page, Heather, and Allison Dickson. "Seawater Acid-Base Chemistry and Ocean Acidification." *Scripps Classroom Connection*. Scripps Institution of Oceanography, n.d. Web. 09 Mar. 2014.

Videos at NSF. "Ocean Temperatures -- Changing Planet." *YouTube*. National Science Foundation, 17 Mar. 2011. Web. 09 Aug. 2016.

Chemical Supplies Needed:

500 mL Beakers

250 mL Beakers

100 mL Beakers

50 mL Beakers

Universal Indicator (8-oz bottle, Amazon.com - $10.98)

Phenopthalein (25g, Amazon.com - $9.49)

Alka-seltzer

Several gallons distilled water

Several gallons seawater

One pale of sand

Seashells

*I had students bring in their own materials for the experiment they designed. Most of these were easy to household items.

Appendix A

pH Calculations

1) Determine the pH of the following solutions:

a) A 4.5 x 10^{-3} M HBr solution.

b) A 3.67 x 10^{-5} M KOH solution.

c) A solution made by diluting 25 mL of 6.0 M HCl until the final volume of the solution is 1.75 L.

d) 5 L of an aqueous solution that contains 1.0 grams of HBr and 1.0 grams of nitric acid.

2) What are the pOHs for the solutions in problem 1?

a) ______________________________

b) ______________________________

c) ______________________________

d) ______________________________

3) Explain why even a basic solution contains some H^+ ions.

4) Explain why even an acidic solution contains some OH^- ions.

5) More challenging: What is the pH of a 1.5×10^{-10} HBr solution?

6) Does your answer from problem #5 make sense? Explain.

pH Calculations – Answers

1) Determine the pH of the following solutions:

a) A 4.5 x 10^{-3} M HBr solution.

2.4

b) A 3.67 x 10^{-5} M KOH solution.

9.56

c) A solution made by diluting 25 mL of 6.0 M HCl until the final volume of the solution is 1.75 L.

1.1 (the diluted solution is 0.086 M HCl)

d) 5 L of an aqueous solution that contains 1.0 grams of HBr and 1.0 grams of nitric acid.

2.2 (the solution has an overall acid concentration of 0.0056 M)

2) What are the pOHs for the solutions in problem 1?

a) **11.6**

b) **4.44**

c) **12.9**

d) **11.8**

3) Explain why even a basic solution contains some H^+ ions.

All aqueous solutions contain H^+ ions from the autoionization of water, $H_2O \rightarrow H^+ + OH^-$.

4) Explain why even an acidic solution contains some OH^- ions.

The same answer from #3 applies here.

5) More challenging: What is the pH of a 1.5×10^{-10} HBr solution?

If you do the calculation to find –log (1.5×10^{-10}), you get an answer of 9.8. However, this is intuitively incorrect – after all, how can a solution that's made of nothing but pure water (pH = 7) with an acid added be basic overall? The answer, it can't. The actual pH of the solution is just about 7, with the main acid source being the H^+ formed from the autoionization of water.

6) Does your answer from problem #5 make sense? Explain.

See answer from #5.

Appendix B
Acid and Base Worksheet

1) Using your knowledge of the Brønsted-Lowry theory of acids and bases, write equations for the following acid-base reactions and indicate each conjugate acid-base pair:

   a) $HNO_3 + OH^- \rightarrow$

   b) $CH_3NH_2 + H_2O \rightarrow$

   c) $OH^- + HPO_4^{-2} \rightarrow$

2) The compound NaOH is a base by all three of the theories we discussed in class. However, each of the three theories describes what a base is in different terms. Use your knowledge of these three theories to describe NaOH as an Arrhenius base, a Brønsted-Lowry base, and a Lewis base.

3) When hydrogen chloride reacts with ammonia, ammonium chloride is formed. Write the equation for this process, and indicate which of the reagents is the Lewis acid and which is the Lewis base.

4) Write an equation for the reaction of potassium metal with hydrochloric acid.

5) Borane (BH_3) is a basic compound, but doesn't conduct electricity when you dissolve it in water. Explain this, based on the definitions of acids and bases that we discussed in class.

6) Write the names for the following acids and bases:

a) KOH ________________________________

b) H_2Se ________________________________

c) $C_2H_3O_2H$ ________________________________

d) $Fe(OH)_2$ ________________________________

e) HCN ________________________________

7) Write the formulas for the following chemical compounds

a) ammonium sulfate ________________________________

b) cobalt (III) nitride ________________________________

c) carbon disulfide ________________________________

d) aluminum carbonate ________________________________

e) chlorine ________________________________

Acid and Base Worksheet - Answers

1) Using your knowledge of the Brønsted-Lowry theory of acids and bases, write equations for the following acid-base reactions and indicate each conjugate acid-base pair:

a) $HNO_3 + OH^- \rightarrow$ **$H_2O + NO_3^-$**
HNO_3 and NO_3^- make one pair
OH^- and H_2O make the other

b) $CH_3NH_2 + H_2O \rightarrow$ **$CH_3NH_3^+ + OH^-$**
CH_3NH_2 and $CH_3NH_3^+$ make one pair
OH^- and H_2O make the other

c) $OH^- + HPO_4^{-2} \rightarrow$ **$H_2O + PO_4^{-3}$**
HPO_4^{-2} and PO_4^{-3} make one pair
OH^- and H_2O make the other

2) The compound NaOH is a base by all three of the theories we discussed in class. However, each of the three theories describes what a base is in different terms. Use your knowledge of these three theories to describe NaOH as an Arrhenius base, a Brønsted-Lowry base, and a Lewis base.

- **NaOH is an Arrhenius base because it creates OH^- ions when placed in water.**
- **NaOH is a Brønsted-Lowry base because it accepts H^+ ions from acids.**
- **NaOH is a Lewis base because the lone pairs on the hydroxide ion can be donated to other compounds.**

3) When hydrogen chloride reacts with ammonia, ammonium chloride is formed. Write the equation for this process, and indicate which of the reagents is the Lewis acid and which is the Lewis base.
$HCl + NH_3 \rightarrow NH_4Cl$
NH_3 is a Lewis base because it uses its lone pair electrons to pull a hydrogen atom from hydrochloric acid.
HCl is a Lewis acid because it accepts electrons from NH_3 when the H is transferred.

4) Write an equation for the reaction of potassium metal with hydrochloric acid.
$2\ K + 2\ HCl \rightarrow 2\ KCl + H_2$

5) Borane (BH_3) is a basic compound, but doesn't conduct electricity when you dissolve it in water. Explain this, based on the definitions of acids and bases that we discussed in class.
Borane is a Lewis base, but a negligibly strong Brønsted-Lowry base.

6) Write the names for the following acids and bases:

a) KOH **potassium hydroxide**

b) H_2Se **hydroselenic acid**

c) $C_2H_3O_2H$ **acetic acid**

d) $Fe(OH)_2$ **iron(II) hydroxide**

e) HCN **hydrogen cyanide or hydrocyanic acid**

7) Write the formulas for the following chemical compounds (remember, you've still got a pop quiz coming up before the end of next week!)

a) ammonium sulfate **$(NH_4)_2SO_4$**

b) cobalt (III) nitride **CoN**

c) carbon disulfide **CS_2**

d) aluminum carbonate **$Al_2(CO_3)_3$**

e) chlorine **Cl_2**

Appendix C

Chemistry Lab Report Format

General Information:

12 pt Times New Roman font
Double Spaced
1 inch margins
Always write in third person
Write in Full Sentences except for the materials list
Check Spelling
Avoid personal pronouns
Headings should stand out and each section should be separated by 1 line
Neatness counts -> use rulers when needed (especially when using tables and graphs), type if possible
Do not copy verbatim (word for word) from the lab handout or any other source. This is plagiarism and would result in a zero mark and possible further consequences.

Title- Heading, Name, Name of Partners, Class Name, Teacher Name, Date Lab Report

Introductory Paragraph – This section should be written in complete sentences and should connect lab concepts to class content, The introduction should provide background information on the history of the concepts tested, scientists, theories, and any laws tested in the experiment. Cite Sources Used. The introduction should contain any prior knowledge on which the experiment is based including an explanation of principles, definitions, experimental techniques, theories and laws.

State Problem / Purpose - The objective is a concise statement in complete sentences outlining the purpose of the experiment. The purpose section of a lab is where you tell the reader your reason for doing the lab in the first place and briefly summarize any relevant background information about the experiment, including any relevant chemical equations and/or algebraic equations.

Hypothesis: Possible if____ then_____ statement. Define any variables such as manipulated, measured, controlled and the cause and effect predicted. The hypothesis is a one-line sentence where you discuss how you'll solve the problem at hand. The statement after "if" is the independent variable. The independent variable is whatever you will do to solve the problem. The statement after "then" is the dependent variable, because what happens will depend on what you did in the first place. Generally, the dependent variable will be the problem you mentioned in the purpose.

Materials: (Bulleted List) The materials section is a list of all equipment, reagents (chemicals), and computer programs that were used to complete the experiment. Drawings of the apparatus setup should be included in this section if needed. The materials list must be complete. Indicate how much of each material will be used in the experiment. If you plan on arranging some of the equipment into a more complex setup (for example, if you are going to heat something over a Bunsen burner, you will need a ring stand, wire gauze, etc.), draw it as well as mention the equipment used.

Procedure: This section may be written in either paragraphs or numbered steps. Explain the test design, and allow for pictures and diagrams. The procedure is a detailed statement (step by step) of how the experiment was performed such that the experiment could be repeated using your report. Safety precautions that were followed should be stated in this section. The procedure must be written in the impersonal (3rd person) past tense: e.g. We are taking the temperature every 2 minutes. NO The temperature was taken every 2 minutes. YES

Data / Results / Observations: This is a collection of observations, measurements, multiple trials, data tables, charts, and repeating steps. This section may consist of quantitative and/or qualitative observations of the experiment. A qualitative piece of data is a written description and/or sketch of what was seen during the experiment. Quantitative information may be in the form of a table or simply a written description. When graphs are required, special attention should be paid to the following items: the type of graph expected (straight line or curve), utilizing the entire graph paper, plotted point size, title of the graph, and axis labels. When numerous measurements have occurred, data is to be placed in a data table whenever possible. Figure headings are placed below the figure and should give a short description of the figure. The figure number should be in bold print. Table headings are found above the table and should also have a brief description.

Analysis / Calculations: Graphs, Error Calculations, Equations, Statistical Analysis - One example of each type of calculation should be included. Results from numerous calculations should be placed in a data table with the proper number of significant figures and correct units. % yield and % error calculations should be included when possible.

Conclusion: The conclusion is a concise statement that answers the objective. The result of percent error and/or percent yield should be discussed and compared with known results. A portion of the conclusion should be dedicated to error analysis which discusses any possible sources of error that may have contributed to the percent error or yield. The conclusion should be written in the impersonal past tense.How to change the experiment for improved results, What did you learn? Explain what the results are telling you, Accept/Reject Hypothesis, Answer any Questions posed by the lab or teacher. A one-line sentence that supports the hypothesis or states that the hypothesis is incorrect. For example, if you proved the hypothesis that “If I poke myself in the eye, then my eye will hurt”, this first sentence would be “When I poked myself in the eye, it hurt.” If the hypothesis didn’t work, an explanation of what possibly went wrong. These should be specific suggestions (I should have heated the mixture to 550 C), not general suggestions (I should have heated it more). List at least two possible errors in the lab, as well as ways to prevent those errors in the future. The errors you mention should be errors that you can do something about, not mystical errors that probably did not occur.

Additional Notes:

Reports will be graded largely on their ability to clearly communicate results and important conclusions to the reader. You must, of course, use proper English and spelling, along with comprehensible logic and appropriate style. You should proofread your report as well as spell-check it.

-Neatness and organization will also influence the grade a report receives. Be sure to follow explicitly the format indicated above. Type reports, and attach lab notes as appendices.

-Avoid being overly verbose and flowery when attempting to convey your point – be concise.

-Avoid qualitative phrases such as "the results were quite close" or "heat fluxes were in good agreement with the correlation." Be as quantitative as possible.

- Do not copy material without citing the source. This includes lab manuals, text books, your neighbor, old labs, etc. Plagiarism, of any degree, will not be accepted.

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