Experiment 1A

FV 8/18/09

MEASUREMENTS AND DATA TREATMENT

MATERIALS: 600 mL beaker, ring stand, Bunsen burner, digital thermometer, thermometer clamp, stirring rod, and ruler.

ADDITIONAL READING: Before coming to lab, read Appendices B and D from the Plebe lab website.

PURPOSE: In this experiment, the student will learn how to do the following.

1. Collect and record experimental data.
2. Report data with the proper number of significant figures.
3. Manipulate and analyze data using Excel.
4. Plot data using the appropriate format and analyze the data using linear regression.

PROCEDURE: Express all data with the proper number of significant figures and units.

Part A. *Relationship between Fahrenheit and Celsius Temperature Scales.*

Fill the 600 mL beaker with an ice/water mixture and place it on the ring stand. Clamp two digital thermometers to the ring stand and immerse them half way into the beaker. Set one thermometer to read Fahrenheit (°F) and the other to read Celsius (°C).

When the temperature readings have stabilized, record them below using the *proper number of significant figures and units*. Remove all of the ice and refill the beaker with tap water. Re-immerse the thermometers and record the temperature in °F and °C when stabilized. Using a Bunsen burner, slowly raise the temperature of the water 12 to 15°C. Record the °C temperature and the corresponding °F temperature. Gentle stirring with a stirring rod should help to equilibrate the temperature. Repeat the warming process in 20°C increments until the water is boiling. Record the temperature readings after each heating in the spaces provided using the proper number of *significant figures and units*.

Fahrenheit	Celsius
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

Part B. *Relationship between inches and centimeters.*

Carefully measure the length in both inches and centimeters of 5 items you find in the lab. This means that you should estimate one digit more than the lines on the ruler, so that if a ruler is marked to 0.1 cm, your measurement should have 2 digits to the right of the decimal point (i.e. 5.25 cm). Record the values in the spaces provided using the proper number of *significant figures and units.*

Inches	Centimeters
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

DATA TREATMENT

Unless otherwise indicated by your instructor, all data in this experiment will be analyzed using Excel*.

Part A. *Relationship between Fahrenheit and Celsius Temperature Scales.*

(A.1) Enter your experimental data from Part A into a spreadsheet. To determine the relationship between the Fahrenheit and Celsius temperatures, plot a graph of temperature in °F versus temperature in °C. (Note, it does not matter which variable is designated as the dependent variable; for simplicity, the temperature in °F has been chosen as the dependent variable and the temperature in °C as the independent variable). Label the axes appropriately. Note, experimentally determined data are only shown as points or markers on the graph, do not use the format that includes a line between points.

(A.2) Due to scatter in these data, it may be difficult to determine whether there is a linear relationship between the temperature in °F and temperature in °C. The equation for a straight line has the form

$$y = m\,x + b$$

where y is the dependent variable, x is the independent variable, m represents the slope of the line, and b represents the y-intercept of the line. An unambiguous way to determine if there is a linear relationship between the dependent and independent variables is to perform a linear regression on these data. From the linear regression output, the correlation value, R^2 can be determined; the closer the value of R^2 is to 1.0, the more linear these data. Perform a linear regression on these temperature data to obtain values for R^2, the slope, and the y-intercept for the line that best fits your experimental data (i.e., the best-fit line). Record these values below with the proper number of *significant figures and units*.

R^2 =

m =

b =

(A.3) For each value of the independent variable in your spreadsheet, use the values for the slope and the y-intercept to determine the corresponding value of the dependent variable that lies on the best-fit line. Do this calculation by entering the equation in your spreadsheet, not by using a calculator then typing in the answers. Next, use the calculated values of the dependent variable to plot the best-fit line on your graph along with your experimental data. Note, points or markers should not be visible in the linear regression line.

(A.4) Because the R^2 value is close to 1.0, these data are linearly related and the relationship between the temperature in °F and temperature in °C can be expressed as °F = m (°C) + b. Use your values of m and b to write out the mathematical relationship between Fahrenheit and Celsius temperatures below.

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* For help with Excel, go to http://www.chemistry.usna.edu/plebeChem/excel_tutor/index.htm.

Part B. *Relationship between inches and centimeters.*

(B.1) Enter your experimental data from Part B into a spreadsheet. Label the columns in the spreadsheet appropriately.

(B.2) Construct a plot of centimeters vs. inches. Note that this means that centimeters is the dependent variable. Perform a linear regression analysis on these data. Record the values below with the proper number of *significant figures and units* and give the equation of the line in the format cm = m (in) + b.

m =

b =

R^2 =

Line:

(B.3) Add two more columns to your spreadsheet. Label them in^2 and cm^2 and <u>use the spreadsheet program</u> to calculate these values. Make sure that you set the cells to show the appropriate number of significant figures.

(B.4) From your results, write out the mathematical relationship between cm^2 and in^2 in the form y = m x + b (continue to use cm as the dependent value).

According to your equation, what is the conversion factor for in^2 to cm^2?

POSTLAB QUESTIONS
Experiment 1A

Part A. *Relationship between Fahrenheit and Celsius Temperature Scales.*

(A.1) Using your experimentally established relationship from *Part A* of this experiment, determine the Fahrenheit temperature that corresponds to a temperature of 275°C.

(A.2) The correct equation for the relationship between the temperatures in °F and °C is give by, °F = 1.8 (°C) + 32. Using this equation, calculate the Fahrenheit temperature that corresponds to a temperature of 275°C.

(A.3) Calculate the % error for your experimentally determined value obtained in part (A.1) from the theoretical value determined in part (A.2).

(A.4) What experimental sources of error might exist in *Part A* of this experiment?

Part B. *Relationship between inches and centimeters.*

(B.1) Use unit analysis to calculate the conversion factor for in^2 to cm^2 from the conversion factor 2.54 cm/in.

(B.2) Calculate the percent error between your actual and measured conversion factors.

(B.3) Does your percent error agree with the number of significant digits in your calculated conversion factor? Explain.

CHEMISTRY LABORATORY SAFETY AGREEMENT

Before working in the chemistry laboratory, read carefully the safety precautions and techniques for handling chemicals described in http://www.chemistry.usna.edu/manual/safety.pdf. **Give this agreement, signed and dated, to your laboratory instructor on the first day of lab.**

When you are in the laboratory, THINK about what you are doing at all times.

1. Always wear approved chemical splash goggles and lab aprons in the laboratory.

2. Do not attempt any unauthorized experiments. Follow directions carefully.

3. Know the location and operation of safety equipment.

4. Bring only necessary materials into lab. Book bags, jackets, covers, etc., are to be left in the hallway.

5. Never work alone in the laboratory.

6. Never eat or drink in the laboratory. Do not bring water bottles into the laboratory.

7. Use the fume hood for experiments. Keep lab stools at the tables, NOT by the hoods.

8. Keep your work area uncluttered. Clean up your area before leaving lab. Lower the hood sashes when not in use.

9. Use only equipment that is in good condition.

10. Dispose of waste and excess materials according to your laboratory instructor's directions.

11. No horseplay in the laboratory.

12. Do not sit or lean on laboratory work surfaces.

13. Handle chemicals with caution.
    (a) Read labels carefully.
    (b) Use only the amount required.
    (c) Leave reagent containers in their proper places.
    (d) Clean up all spills immediately.
    (e) Label all chemical containers.

14. Thoroughly wash your hands any time you leave the laboratory.

15. Immediately report all accidents and physical/chemical injuries, no matter how minor, to your laboratory instructor. Be ready to take immediate action as needed to assist any injured classmate.

16. Do not leave the laboratory without your instructor's approval.

I have carefully read all the safety precautions on the pages at the website above and recognize that it is my responsibility to observe them throughout my chemistry course.

Name _____ Signature _____

Course _____ Section _____

Instructor _____ Date _____