Error analysis lab

Error Analysis Lab By: Lab Team 5 Introduction and Background: In the process of learning about the importance of measurement and data processing, lab teams were given prompts to design experiments as well as address the precision, accuracy, and error analysis within the experiment. Lab teams collaborated their data to find similarities and differences within their measurements. Through this process, students learned the importance of the amount of uncertainty as well as the different types of experimental errors that might have caused a margin of difference within the lab teams results.

Measurement and data processing is a topic discussed in IB Chemistry SL; it is important within the scientific community as it discusses the reliability of the data presented. Uncertainty is used to determine a range of a value in a measurement or instrument. Uncertainty of an analogue instrument is plus or minus half of the smallest division present; while uncertainty of a digital scale is plus or minus the smallest division present. To identify the amount of uncertainty, significant figures (the digits in measurement up to and including the first uncertain digit) are used.

Certain rules are used to discover the number of significant figures in a value: * 1-9 are always significant * included zeroes (1009= 4 significant figures) * leading zeroes never count (0. 023= 2 significant figures) * trailing zeroes after the decimal count (1. 9850= 5 significant figures) Experimental errors are the difference between recorded value and generally accepted or literature value. There are two types of experimental errors: random and systematic errors. Random errors are caused by the readability of a measuring instrument, the effects of changes in the surroundings, insufficient data, and observer misinterpretation.

Systematic errors are errors that can not be reduced by repeating experiments or careful experimental design. These errors are caused by poor experimental design as well as improper measurement techniques. Accuracy is the difference between the experimental value and the accepted value. The greater the accuracy, the smaller the systematic error. Precision is the reproducibility of the experimental value. The greater precision, the less the random uncertainties. Purpose: Design laboratories based upon ideas of accuracy, precision and error analysis through creating a procedure and addressing the prompts.

Materials: * 13. 5 cm x 10 cm sheet of aluminum foil * Ruler * Balance * Laptop * Micrometer * Silver Cube of Unknown Solid * H2O (via sink) * Timer * Thermometer (in degrees Celsius) * 500 sheets of paper * Caliper * 100 mL graduated cylinder * 10 mL graduated cylinder * 25 mL flask Procedures and Methodologies: Station One (find volume, mass, and density of an unknown cube): 1 Find the height of the silver cube of unknown solid using the micrometer. 2 Find the length of the silver cube of unknown solid using the micrometer. 3 Find the width of the silver cube of unknown solid using the micrometer. Find the mass of the silver cube of unknown solid using the balance. 5 Using the measured length, width and height of the cube of unknown solid, calculate the volume of the cube. 6 Divide the mass of the cube by the volume to find the density of the cube. 7 Using the laptop, identify the type of metal based on the density. Station Two (find a way to measure 10. 5mL of water): 1 Using the 10 mL graduated cylinder, measure out 10 mL of water. 2 Pour the measured water into the 100 mL graduated cylinder. 3 Using the 10 mL graduated cylinder, measure 0. 5 mL of water. Pour the measured water into the 100 mL graduated cylinder, combining with the previously measured 10 mL of water. Station Three (measure the thickness of single sheet of paper and volume of 500 sheets): 1 Measure the height of the stack of paper with the ruler in millimeters (mm). 2 Measure the length of the stack of paper with the ruler in mm. 3 Measure the width of the stack of paper with the ruler in mm. 4 Calculate the volume of the stack of paper using the ruler's dimensions in millimeters. 5 Calculate the thickness of one sheet of paper based on the ruler's dimensions. Divide the height by number of sheets of paper [500 sheets]). 6 Repeat steps 1-5, instead using the caliper for measurements, but still measuring in millimeters. Station Four (calculate the volume of metal cylinder): 1 Using the caliper, measure the height of the cylinder in millimeters. 2 Using the caliper, measure the diameter of the cylinder's circle in millimeters. 3 Using the volume of a cylinder formula (pi x radius squared x height), calculate the volume of the cylinder. Station Five (Calculate the thickness of aluminum foil): 1 Using a laptop, determine the accepted density for aluminum. Using the electronic balance, measure the mass of the sheet of aluminum foil. 3 Divide the mass by the accepted density to determine the volume. 4 Using the ruler, measure the dimensions (length x width) of the sheet of aluminium. 5 Divide the volume by the dimensions of the aluminum to determine the thickness. Station Six (Measure the temperature of the sink water for 120 seconds): 1 Turn hot water knob on. 2 Hold thermometer under running water. 3 Record temperature at 60 seconds. 4 Record temperature at 90 seconds. 5 Record temperature at 120 seconds. 6 Remove thermometer from water.

Station Seven (Determine the circumference, density, and identity of wire): 1 Using the micrometer, find the diameter of the of the wire 2 Multiply the diameter by pi (3. 14) to find the circumference of the wire 3 Using the ruler, find the length of the wire 4 Using the balance, find the mass of the wire 5 Multiply the circumference and the height of the wire to determine the volume 6 Divide mass by volume, to determine the density of the wire. 7 Using the laptop, identify the type of metal based on the density Data Collection: Station One- The results from measuring the volume, mass, and density of a unknown cube .

Using the density, the lab teams were able to identify the unknown cube. Group| Data| 1| volume= 530 +- . 15mm3, mass= 7. 1+-. 05g, density= 0. 12+-. 011gmm-3, lead| 2| volume= 653+-. 01mm3, mass= 7. 1+-. 1g, density= 0. 01gmm-3, lead| 3| volume= 580+-100mm3, mass 7. 14+-0. 001g, density= 0. 012gmm-3, lead| 4| volume= 748+-0. 005mm3, mass= 7. 13g, density= 0. 0009gmm-3, lead| 5| volume= 727+-1mm3, mass= 7. 14+-. 01g, density= . 01gmm-3, lead| 6| volume= 621+-0. 05mm3, mass= 7. 15+-0. 01g, density= 0. 0115gmm-3, lead| Station Two- Using the different graduated cylinders, lab teams measured out 10. 5 mL of water. Group| Data| 1| 10. +-. 5mL| 2| 10. 5+-. 1mL| 3| 10. 5+-. 05mL| 4| 10. 5+-. 5mL| 5| 10. 5+-. 5mL| 6| 10. 5+-. 5mL| Station Three- Provided with a ruler and micrometer, teams found the thickness of a single sheet of paper and the volume of 500 sheets of paper. Group| Data| 1| thickness= 0. 01cm, volume= 2950cm3| 2| thickness= 0. 01cm, volume= 6. 0cm3| 3| thickness=

0. 01cm, volume= 3100cm3| 4| thickness= 0. 0096cm, volume= 2900cm3| 5| thickness= 0. 01cm, volume= 3100cm3| 6| thickness= 0. 0098cm, volume= 2950cm3| Station Four- Given a metal caliper, students were asked to find the volume of a cylinder. Group| Data| 1| volume= 39+-2cm3| 2| volume= 38. +-2cm3| 3| volume= 63+-4. 9cm3| 4| volume= 39+-2 cm3| 5| volume= 41+- 1cm3| 6| volume= 38. 8+-. 1cm3| Station Five- Students calculated the thickness of a piece of aluminum foil using a balance and ruler. Group| Data| 1| 0. 0018+-0. 0002cm| 2| 0. 01646+-0. 0002cm| 3| 0. 0017+-0. 00002cm| 4| 0. 0022+-0. 00005cm| 5| 0. 00175+-0. 00005cm| 6| 0. 0018cm| Station Six- Lab teams measured the temperature of sink water over 120 seconds. Group| Data| 1| Start= 23+-. 5C, 60= 22+-. 5C, 90= 22+-. 5C, 120= 22. 5C| 2| Start= 21. 0+-. 5C, 60= 21. 2+-. 5C, 90= 21. 5+-. 5C, 120= 21. 7+-. 5C| 3| 60= 21+-. 5C, 90= 22+-. 5C, 120= 23+-. 5C| 4| 23+-. 5C| | 60= 29C+-. 5, 90= 29+-. 5C, 120= 29+-. 5C| 6| Start= 21. 5C, 60= 22C, 90= 22. 25C, 120= 22. 5C| Station Seven- Using a micrometer, balance, and ruler, groups were asked to calculate the circumference, density and discover the identity of a wire. Group| Data| 1| circumference= 6. 3+-+. 5mm, identity= copper, density= 0. 0033gmm-3| 2| circumference= 1. 19pi mm, identity= copper, density= 0. 011gmm-3| 3| circumference= 3. 14mm, identity= copper, density= 0. 13gmm-3| 4| circumference= 3. 93mm| 5| circumference= 3. 14 mm, identity= copper, density= 0. 13gmm-3| 6| circumference= 1. 23pi mm, identity= copper, density= 0. 307gcm-3|

Error Analysis: Station 1 (find volume, mass, and density of an unknown cube) In this particular station, there are no identified outliers. While the mass and density were rather close in value, there was no close range in the measurement of the volume of the unknown cube. This can be seen in the graphs below. Some random errors that may have caused this lack of precision in finding the volume of the unknown cube are misreadings of the instruments, changes in theenvironmentof the experiment, the number of significant figures used, and the experimenter approximating a reading. Station 2 (find a way to measure 10. 5mL of water)

In this station, there were two identifies outliers. This included Group 2 and Group 3. They were identified as outliers because of the amount of uncertainty. This two groups had a rather small amount of uncertainty unlike the other four groups with identical amounts of uncertainty. This can be seen in the graph below. The error that would have caused the amount of uncertainty is systematic because water will have clinged to the sides of the graduated cylinder as it was emptying. Another reason it was a systematic error was the fact that too much water could have been added to the graduated cylinder as it was filled.

Station 3 There is only one large outlier within this station. In measuring the volume, Group 2 measured the volume to be 6. 0 cm3 while all other groups said the volume was around 3000cm3. This is such a huge gap that it would not be counted as a valuable measurement. Errors that could have occurred in this lab could have been random like the mismeasurement of the volume. The error could have also occurred by the misinterpretation of the question or prompt given. Station 4 The outlier in this station is group 3 with a Station 5 Station 6 Station 7

Conclusion and Evaluation: In result of the preformed lab, our team learned the importance of determining error as well as preventing the majority of this error. The large range of results most likely was a result of systematic error. This can be concluded because there were no set directions for each station, and a different procedure could have been used by each lab team. Another source of error can be seen in the difference in sig figs used between groups. Random error most likely was a result of the unfamiliar tools that were used for the first time by many students.