In this experiment, you will determine the mass percent of carbon produced in the decomposition of sodium bicarbonate produced from the following chemical equation: Reacting sodium bicarbonate (sodium hydrogen carbonate) with sulfuric acid will produce a salt, water, and carbon dioxide gas. According to the Law of Definite Composition, the mass percentage of carbon produced by the bicarbonate should be constant no matter how much sodium bicarbonate is being decomposed. The experiment should be performed two times and the results averaged. SAFETY Wear safety goggles in the lab at all times. Wash your hands immediately upon contact with chemicals. PROCEDURE 1. Place an empty, dry 100 mL beaker on the balance pan. Zero the balance. 2. Add approximately 0.70g of NaHCO3 to the beaker and record the exact mass of NaHCO3. 3. Remove the beaker and zero balance. 4. Place the dropper of 1M H2SO4 and the beaker with the NaHCO3 on the balance. Record the mass as the initial total mass. 5. At your lab station SLOWLY add the H2SO4 to the beaker one drop at a time. Swirl the contents to ensure complete mixing. Continue releasing the acid drops in this manner until effervescence ceases. 6. Place the beaker and dropper on the balance. Record as the final total mass. 7. Discard the contents of the beaker in the sink, rinse and dry the beaker. 8. Repeat procedure for trial two. Table 1: Masses of Reactants and Products Through Trials 1 and 2 Trial 1Trial 2Mass of NaHCO30.71 g0.70 gInitial Total Mass89.12 g85.26 gFinal Total Mass88.68 g84.87 gMass CO20.44 g0.39 g CALCULATIONS 1.) Calculate the mass of CO2 lost in each trial. (initial total mass – final total mass) Trial 1: 89.12 – 88.68 = 0.44 g Percent Composition Lab: ExplainedTrial 2: 85.26 – 84.87 = 0.39 g 2.) Calculate the theoretical % C in CO2. Remember to round all % to two digits after the decimal. Atomic Mass of C: 12.01 g/mol Atomic Mass of O: 16.00 g/mol → 2 M of Oxygen = 32.00 g/mol Mass of Compound: 1C + 2O = 12.01 + 32.00 g/mol = 44.01 g/mol Mass % of C = 12.01/44.01×100=27.29% 3.) Calculate the actual mass C for each trial. (%C as decimal X mass of CO2) Trial 1: Mass % of C: 27.29% Mass of CO2: 0.44 g Mass of C = 0.2729 x 0.44 = 0.12 g Trial 2: Mass % of C: 27.29% Mass of CO2: 0.39 g Mass of C = 0.2729 x 0.39 = 0.11 g 4.) Calculate the %C for each trial. (mass C/mass NaHCO3). Remember to round all % to two digits after the decimal. %C for Trial 1: 12.00/0.71 = 16.90 % %C for Trial 2: 11.00/0.7 = 15.71 % 5.) Calculate the average % C. 16.90 + 15.71 = 32.61 32.61/2 = 16.31 Average Percent of Carbon = 16.31% 6.) Calculate the theoretical %C in NaHCO3. Remember to round all % to two digits after the decimal. %C = 12.01(100)/(Na + H + C + 3O) %C = 12.01(100)/(22.99 + 1 + 12.01 + 3(16)) %C = 12.01(100)/84 %C = 14.30% 7.) Calculate your % error. [(|actual-theoretical|/theoretical) x 100] [(|actual-theoretical|/theoretical) x 100] = [(|16.31-14.30|/14.30) x 100] = 14.06 % Questions: 1.) What effects would there be in your results if you did not decompose all of the sodium hydrogen carbonate in each of your trials? Would the percentage of C that you determine be lower or higher than it should have been? Our results would not be as accurate or completely correct if we did not decompose all of the sodium hydrogen carbonate in our trials. This is because with the Law of Definite Composition, there is a specific amount of each element found in a chemical compound where the percentage composition is constant. Since a specific amount is required with the formation of a compound, in this case CO2, this law also applies with the decomposition of a compound. If a specific compound is decomposed, the precise amounts of each element within the compound should be produced. If the compound (Sodium Hydrogen Carbonate) was not fully decomposed (dissolved), then there may be the possibility that all precise amounts of the element are not completely separated then the expected amount will not be produced. The percentage of Carbon would be lower than it should have been if the decomposition process is not thoroughly completed. Percent Composition Lab: Explained2.) If we used this experiment to determine the % of C in various brands of sodas, would you expect the results to illustrate the Law of Definite Composition? Why or Why not? It would be expected that if this experiment was conducted to determine the % of C in various brands of soda, it would illustrate the Law of Definite Composition. This is because as the Law of Definite Composition states that regardless of the amount, a chemical compound will always contain the same elements in the same proportions by mass. The element of Carbon remains the same, no matter what. Therefore, putting it together with different types of sodas that may have different masses of CO2 altogether, the percentage composition of Carbon will still remain the same based on the total mass of CO2. Methyl salicylate C6H4 (HO) COOCH3, also known as salicylic acid methyl ester, oil of wintergreen, is a natural product of many species of plants. Methyl salicylate may be used by plants as a pheromone to warn other plants of pathogens such as tobacco mosaic virus. Methyl salicylate is used in deep heating liniments and in small amounts as a flavoring agent. Oil of wintergreen is used in the field of medicine in aromatherapy. To synthesize methyl salicylate by esterification of acetylsalicylic acid with methanol. To separate the synthesized methyl salicylate Bottle of aspirin, methanol, concentrated sulfuric acid, sodium bicarbonate, Ether, mortar and pestle, scintillation vials, pipettes, graduate cylinder, hot plate. Always wear goggles and gloves Work under fume hood Do not breathe vapors of methanol and ether Handle concentrated sulfuric acid with care. If spilled on your skin wash immediately with plenty of water. Weigh two tablets of aspirin on the analytical balance scale to 0.01 gram. Place in mortar and decompose the aspirin to a powder form. Pour the powder aspirin into a scintillation vial. Add 5 ml of methanol. Add 4 drops of concentrated sulfuric acid to the bottle. Gently swirl so the contents are thoroughly mixed. Be careful the reaction is exothermic. Gently warm on hot plate for approximately 5 minutes. Cool down and then neutralize the salicylic acid with sodium bicarbonate. Add one drop at a time until the reaction stops fizzing. Use ether (or any other solvent available) Do several extractions to remove by products For each extraction two layers form. The top layer is ether and the bottom layer is water/ methanol Remove top layer with pipette. Continue to evaporate the ether by a water bath in the fume hood. After evaporation the smell of methyl salicylate is produced How many moles of salicylic acid and methanol are used in this experiment? Salicylic Acid: 0.74 g / 138.121 g/mol = 5.36 x 10^-3 moles Methanol: 0.005 L x 0.998 mol/L = 4.99 x 10^-3 moles Draw the two functional groups found in esters? Esters are made from carboxylic acid and alcohols R-CO-OR made from R-COOH and R-OH What is the purpose of concentrated sulfuric acid in an esterification reaction? The purpose of the sulfuric acid is to act as a catalyst. In esterification, an ester is formed by the reaction between an alcohol and an organic acid (usually a carboxylic acid). The reaction typically involves the removal of a water molecule (dehydration) to form the ester. Sulfuric acid acts as a catalyst by protonating the carboxylic acid, generating a more electrophilic carbonyl group. This makes the carbonyl carbon more susceptible to nucleophilic attack by the alcohol. The sulfuric acid can also abstract a water molecule from the reaction mixture, driving the equilibrium towards ester formation. The dehydration of the reaction mixture is essential because water, which is produced as a byproduct in the esterification reaction, can hydrolyze the ester back into the starting materials. Removing water through dehydration shifts the equilibrium of the reaction in favor of the ester product. Write the neutralization reaction between sulfuric acid and sodium bicarbonate H2SO4 + $NaHCO_3$ -> Na2SO4 + H2O + CO2 Which substance is the limited reagent in the esterification reaction? Explain! Salicylic acid + Methanol → Methyl Salicylate $C_7H_6O_3$ + CH_3OH → $C_8H_8O_3$ + H2O The stoichiometric coefficients of each reactant is 1 This means that the reactants will react evenly with each other Amounts of each substance: Salicylic Acid: 5.36 x 10^-3 moles Methanol: 4.99 x 10^-3 moles Since both of these reactants react at the same rate (x moles of Salicylic Acid reacts with x moles of Methanol), it is evident that Methanol is the limit reactant because it will be fully reacted before all of the Salicylic Acid reacts. It will leave (5.36 x 10^-3 – 4.99 x 10^-3) 3.7 x 10^-4 moles of Salicylic Acid unreacted. What is the percent yield of methyl salicylate? Theoretical value: Since Methyl Salicylate is produced at a 1:1 ratio with either of the reactants, the amount of moles of Methyl Salicylate produced will be equal to the moles of limiting reactant available, which in this case is 4.99 x 10^-3 moles. 0.00499 moles x 152.1494 g/mol = 7.59 g Actual value: 0.0035429 moles of methyl salicylate 0.0035429 moles x 152.1494 g/mol = 5.39 g Actual Value/Theoretical Value x 100 = % Yield 0.0035429/0.00499 x 100 = 71% Why is the percent yield of the product either too high or low? Evaporated off What are the two additional byproducts produced in the synthesis of methyl salicylate? Acetic acid and water What is the purpose of the extraction technique in this lab? Extract the ester using an ether The scientific method is demonstrated by exploring the change in mass of pennies over time. Not unexpectantly, just like normal scientific investigation, the first question leads to a second question and a third question. In the end, young scientists discover that pennies exist as "isotopes" and use the fractions and masses of pennies to verify the isotope equation. FractionP1 × MassP1 + FractionP2 × MassP2 = Average Mass in Sample The first scientific method animation investigates dependence of the change in mass of a penny on year minted. The second animation explores the metallic composition of the penny and similarities between the Penny "isotopes" and atomic isotopes. Follow the directions below to work through both animations: Click the Procedure arrow and follow the directions. The Lab Report provides a place to record lab data and to enter the final calculations. If any of the calculations are incorrect, the correct answer(s) will be displayed for you. When all calculations are correct, a Lab Complete message appears. If required by your instructor, take a screenshot of the completed lab showing the Lab Complete message : Open the Snipping Tool (click on the Start button and type Snip & Sketch in the search box). For MAC OS press Command-Shift-F4 (screenshot) or use the Grab feature located in Applications → Utilities folder. For the Snip & Sketch, click the New button and click / drag a rectangle around the animation - don't include extra white space. Print the 'snip' to give to your instructor, or save it to your computer and send it as an email attachment to your instructor. Unless you're a coin collector, you probably think all United States pennies are pretty much the same. To the casual observer, all the pennies in circulation do seem to be identical in size, thickness, and composition. But just as elements have one or more isotopes with different masses, the pennies in circulation have different masses.In this investigation, you are going to use pennies with different masses to represent different "isotopes" of an imaginary element called pennium, or Pe. Remember that chemical isotopes are atoms that have the same number of protons, but different numbers of neutrons. Thus, chemical isotopes have nearly identical chemical properties, but some different physical properties.In this investigation, you will determine the relative abundance of the isotopes of pennium and the masses of each isotope. You will then use this information to determine the atomic mass of pennium. Recall that the atomic mass of an element is the weighted average of the masses of the isotopes of the element. This average is based on both the mass and the relative abundance of each isotope as it occurs in nature. To determine whether the total mass changes during a chemical reaction. Laboratory balance 25 pennies in a resealable bag Remove the pennies from the resealable bag and count them to make sure that there are 25. Determine and record the combined mass of your 25 pennies. (66.2 g) Find the mass of each penny separately. In the Data Table, record the year the penny was minted and its mass to the nearest 0.01 gram. (NOT 0.1 gram – in other words, round off one decimal). Place the 25 pennies in the resealable bag and return the pennies and the balance to the area designated. Clean up and wash your hands, pennies are dirty! Table 1: Mass of Each Penny by Year Penny #YearMass (g)119623.00 g219693.05 g319733.01 g419733.03 g519773.11 g619813.05 g719823.13 g819852.50 g919882.47 g1019882.50 g1119892.47 g1219892.48 g1319932.49 g1419952.45 g1519952.45 g1619962.51 g1719992.45 g1819992.54 g1920002.50 g2020012.53 g2120042.56 g2220052.48 g2320072.50 g2420132.49 g2520162.48 g Inspect your data carefully. Determine the number of isotopes of Pe that are present (How many different masses of Pe are there?). Two isotopes of Pe are present: Pennies made up until 1982 and pennies made after 1982. Calculate the fractional abundance of each isotope in your sample. To check your math, add up your fractional abundances, they should total to 1. Copper Penny to Silver Lab AnswersFractional Abundance (F.A) =(# of pennies for each isotope)/(Total # of pennies) F.A of Pe-Pre 1982 = 7/25 = 0.28 (28% abundance) F.A of Pe-Post 1982 = 18/25 = 0.72 (72% abundance) Calculate the average atomic mass of each isotope. Average atomic mass =(total mass of pennies of each isotope)/(number of pennies of that isotope) Avg atomic mass of Pe-Pre 1982 = 21.38/7 = 3.05 g Avg atomic mass of Pe-Post 1982 = 44.85/18 = 2.49 g Using the fractional abundance and the average atomic mass of each isotope, calculate the average atomic mass of Pe. Average Atomic Mass = (avg mass isotope #1) x (F.A. #1) + (avg mass isotope 2) x (F.A #2) Average atomic mass of Pe = (3.05 x 0.28) + (2.49 x 0.72) = 2.65 g Was the mass of 25 pennies equal to 25 times the mass of one penny? Explain, using your data. The mass of the 25 pennies was not equal to 25 times the mass of one penny. This is because there are different isotopes of Pe. As observed in the lab, the two different isotopes of Pe had their fractional abundances. The different fractional abundances relate to the proportion of each isotope, meaning that the masses would not be constant between the two isotopes. Therefore, an average atomic mass for each isotope is required to produce an accurate number for the mass of the pennies. In what year(s) did the mass of Pe change? How could you tell? The mass of Pe changed after the year 1982. When recording the mass of each penny by year in Table 1, it was observed that the masses of the pennies shifted after 1982. How can you explain the fact that there are different "isotopes" of Pennium? Use the US Mint website to research. The phenomenon of there being different "isotopes" of Pennium can be explained because of the difference in the material used to construct the pennies. Pennies used to be made out of pure copper. However, in 1982, pennies started to be made with primarily zinc and only 2.5% copper, reducing the mass of the pennies in the process.Why are the atomic masses for most elements, not whole numbers? The atomic masses for most elements are not whole numbers because most of these elements have many different isotopes. The atomic mass of each element is the average mass of all naturally occurring isotopes of the element. How are the three isotopes of hydrogen (hydrogen-1, hydrogen-2, and hydrogen-3) alike? How are they different? The three isotopes of hydrogen are alike because they are all naturally occurring isotopes of the same element. However, they differ in the number of neutrons. Copper Penny to Silver Lab AnswersCopper has 2 isotopes, copper-63 and copper-65. The relative abundance of copper-63 is 69.1% and copper65, 30.9%. Calculate the average atomic mass of copper. Average atomic mass of Cu = (0.691 x 62.93) + (0.309 x 64.93) Average atomic mass of Cu = (43.48) + (20.06) Average atomic mass of Cu = 63.5 amu Clearly explain why we only recorded two decimals when recording the mass of each penny. If we had recorded one decimal, how might our estimate of the number of isotopes of Pennium have changed? The decision to record the mass of the pennies with two decimal places was made to provide reasonable accuracy while keeping the data manageable. If one were to record the masses with one decimal place instead, the mass of the pennies would have to be rounded to the nearest tenth of a decimal. This would cause a change in the data, potentially affecting the number of isotopes found. However, in this case, with Pennium, the masses of the pennies were separated into two distinct groups. As a result, rounding the masses would not significantly impact the results, as there would still be two distinct isotopes of Pennium.Based on the results of the experiment, it appears that there were little to no errors in the execution of the experiment. However, it is worth noting that during the measurement of one of the pennies, the battery for the laboratory scale died. Fortunately, the batteries were replaced and the same scale was used to continue the measurements. It is important to acknowledge that if a different scale had been used at that point, it could have introduced a slight variation in the data, potentially affecting the results to some degree. The primary objective of this experiment was to unravel the masses and relative abundances of isotopes of Pennium (Pe) and to calculate its average atomic mass. Two distinct isotopes of Pe were uncovered by measuring the masses of various pennies. The fractional abundances of these isotopes were calculated to be 0.28 and 0.72, revealing the proportion of each isotope within the sample. Utilizing fundamental chemistry formulas, the average atomic mass of Pennium was calculated to be 2.65 grams. This result confirms the success of the lab objective and emphasizes the vital role of isotopic analysis in comprehending element composition, showcasing the diverse nature of scientific exploration and discovery. Purpose: To find the specific heat capacity of a substance Principle: According to the principle of thermal energy exchange, when thermal energy is transferred from a warmer object to a colder object, the amount of thermal energy released by the warmer object is equal to the amount of thermal energy absorbed by the colder object. Q released =Qabsorbed The quantity of heat required to heat up a substance through T is Q = mcΔT m1 c1 ΔT1 = m2 c2 ΔT2 (or) c1= (m2 c2 ΔT2) / m1 ΔT1 Procedure: Measure the mass of water Measure the initial temperatures of water and cube Drop the cube in water and note the final steady temperature of the system Measure the mass of the cube Repeat the experiment with different cubes Calculate the temperature changes that happen to the water and the cube Calculate the specific heat capacity of each cube Observations: Mass of water m2= 224g = 0.224 kg Specific heat capacity of water c2 = 4200 J / kgC Initial Temp of water (t2) CInitial Temp of cube (t1) 0CFinal Temp of the mixture (T) CMass of cube (m1) kgCube 122.5C -6C18C0.205 kgCube 220.5C -6C20C0.066 kgCube 321C -6C20C0.068 kg Calculations: Determining Heat Capacity of Water Lab Answers ΔT2 = t2 – T (C) (Water)ΔT1 = T – t1 (C) (Cube)c1 = (m2 c2 ΔT2) / m1 ΔT1 J / kg CCube 122.5 – 18 = 4.5C 18 – (–6) = 24C (0.224)(4200)(4.5)/(0.205)(24) = 861.6 J/kg℃Cube 220.5 – 20 = 0.5C 20 – (–6) = 26C (0.224)(4200)(0.5)/(0.066)(26) = 274.1 J/kg℃Cube 321 – 20 = 1C 20 – (–6) = 26C (0.224)(4200)(1)/(0.068)(26) = 532 J/kg℃ The calculated value of specific heat capacity of cube 1 = 861.6 J/kg℃ The calculated value of specific heat capacity of cube 2 = 274.1 J/kg℃ The calculated value of specific heat capacity of cube 3 = 532 J/kg℃ Actual Specific heat capacity of cube 1 = 880 J/Kg℃ (Based on Researched heat capacity for Aluminum) Actual Specific heat capacity of cube 2 = 236 J/Kg℃ (Based on Researched heat capacity for Silver) Determining Heat Capacity of Water Lab AnswersActual Specific heat capacity of cube 3 = 521 J/Kg℃ (Based on Researched heat capacity for Titanium) % error for cube 1 = (Observed – Actual)/Actual * 100% = (861.6-880)/880 *100% = 2.09 % % error for cube 2 = (Observed – Actual)/Actual * 100% = (274.1-236)/236 *100% = 16.14 % % error for cube 3 = (Observed – Actual)/Actual * 100% = (532-521)/521 *100% = 2.11 % Conclusion: In conclusion, the purpose of this lab was to determine the specific heat capacity of a substance by using the principle of thermal energy exchange and the equation Q = mcΔT. By measuring the temperature changes and masses of the substance and water in three separate experiments, we were able to calculate the specific heat capacity of the substance using the equation m1c1ΔT1 = m2c2ΔT2. The accuracy of our results may have been affected by various sources of error, such as heat loss to the surroundings and the assumption of a perfectly insulated system. Nonetheless, this lab provided a valuable opportunity to apply fundamental principles of thermodynamics and to gain practical experience with experimental techniques for measuring thermal properties.