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LAB 1 Specific Heat and Relationship to Atomic Weight of a Metal

Abstract: We will measure the specific heat capacities of several metals and attempt to establish a relationship between their atomic weights and those measured values.

Chemical Equations: None in this activity

Data Collection: Identity of Metal sample copper

Volume of deionized water 100.0 mL

Mass of metal sample 64.737 g

Temperature of metal sample from water bath Trial 1: 99.6 °C Trial 2: 99.7°C

Temperature of water in calorimeter Trial 1: 25.6 °C Trial 2: 29.6° Trial 3: 33.4°C Trial 3: 100.0°C

Temperature of water + copper Trial 1: 30.2°C Trial 2: 33.6°C Trial 3: 36.8

Observations:
Water droplets on side of cup after pouring from volumetric flask
Bubbles cause copper cylinder in boiling flask to move about

Data Calculations: Example $\Delta T$ Temperature of water plus copper minus temperature of water in calorimeter

$30.2 - 25.6 = \boxed{4.6°C}$

Example $c_{sp} = \frac{\text{heat}_{\text{lost or gain}}}{m_{Cu} \cdot \Delta T_{Cu}}$

Specific heat of copper = heat gained by water divided by mass of copper times change in copper temperature

$= \frac{460 \text{ calories}}{(64.737)(69.4)} = \boxed{0.10 \text{ cal/g°C}}$

Mass of water = volume (density @ 25°C) $= (100.0 \text{ mL})(.99707) = \boxed{99.71 \text{ g}}$

Heat gained by water = Mass of water times specific heat of water times change in water temperature

$= (99.71)(1.00)(4.6) = 458.7 \text{ calories}$

$= \boxed{460 \text{ calories}}$

$\Delta T$ for Copper = Temperature of copper in water bath minus temperature of water + copper

$= 99.6 - 30.2 = \boxed{69.4°C}$

## Table of Calculations

| | Trial 1 | Trial 2 | Trial 3 |
|---|---|---|---|
| Mass of Water | 99.71 g | 99.71 g | 99.71 g |
| Change in Water Temp | 4.6 °C | 4.0 °C | 3.4 °C |
| Change in Cu Temp | 69.4 °C | 66.1 °C | 63.2 °C |
| Heat gained by water | 460 cal | 400 cal | 340 cal |
| Specific heat of Cu | 0.10 cal/g°C | 0.093 cal/g°C | 0.083 cal/g°C |

Average Cu specific heat = 0.092 cal/g°C

## Table of Data on other Metals from other lab groups

| Metal | Accepted | Trial 1 | Trial 2 | Trial 3 | Average | Atomic Wt |
|---|---|---|---|---|---|---|
| Fe | .108 | 0.12 | 0.13 | 0.12 | 0.123 | 55.85 |
| Cu | .092 | 0.10 | 0.10 | 0.088 | (use ours) X | 63.55 |
| Pb | .031 | 0.032 | 0.030 | 0.037 | 0.033 | 207.2 |
| Al | .215 | 0.203<br>0.217 | 0.200<br>0.192 | 0.198 | 0.200<br>(use 1st) X | 26.98 |
| Sn | .054 | 0.063 | 0.061 | 0.053 | 0.059 | 118.69 |
| Zn | .093 | 0.098 | 0.092 | 0.11 | 0.10 | 65.38 |

## Analysis of the data

~~Absolute~~ Deviations from ~~Accepted Values~~ Mean

| Metal | Trial 1 | Trial 2 | Trial 3 | Average | Relative |
|---|---|---|---|---|---|
| ~~Fe~~ | ~~0.012~~ | ~~0.022~~ | ~~0.012~~ | ~~0.015~~ | |
| | −0.003 | 0.007 | −0.003 | 0.000033 | 0.27% |
| Cu | 0.008 | 0.001 | −0.009 | 0.00 | 0.00% |
| Pb | −0.001 | −0.003 | 0.004 | 0.00 | 0.00% |
| Al | 0.003 | 0.000 | −0.002 | 0.000033 | 0.17% |
| Sn | 0.004 | 0.002 | −0.006 | 0.00 | 0.00% |
| Zn | −0.002 | −0.008 | 0.010 | 0.00 | 0.00% |

% error for Cu = $\frac{\text{Absolute error}}{\text{Accepted value}} \times 100\%$

Absolute error = Avg. Experimental value − Accepted value

= 0.092 − 0.092 = 0.000

% error = $\frac{0.000}{0.092}$ = 0.00% error

## Probable Errors

One source of error was in the incomplete transfer of water from the measuring device into the calorimeter. Since some may have adhered to the volumetric flask, a smaller volume and thus a smaller mass of water would cause the heat flow into water to be smaller and likewise the specific heat of the metal to be of smaller value.

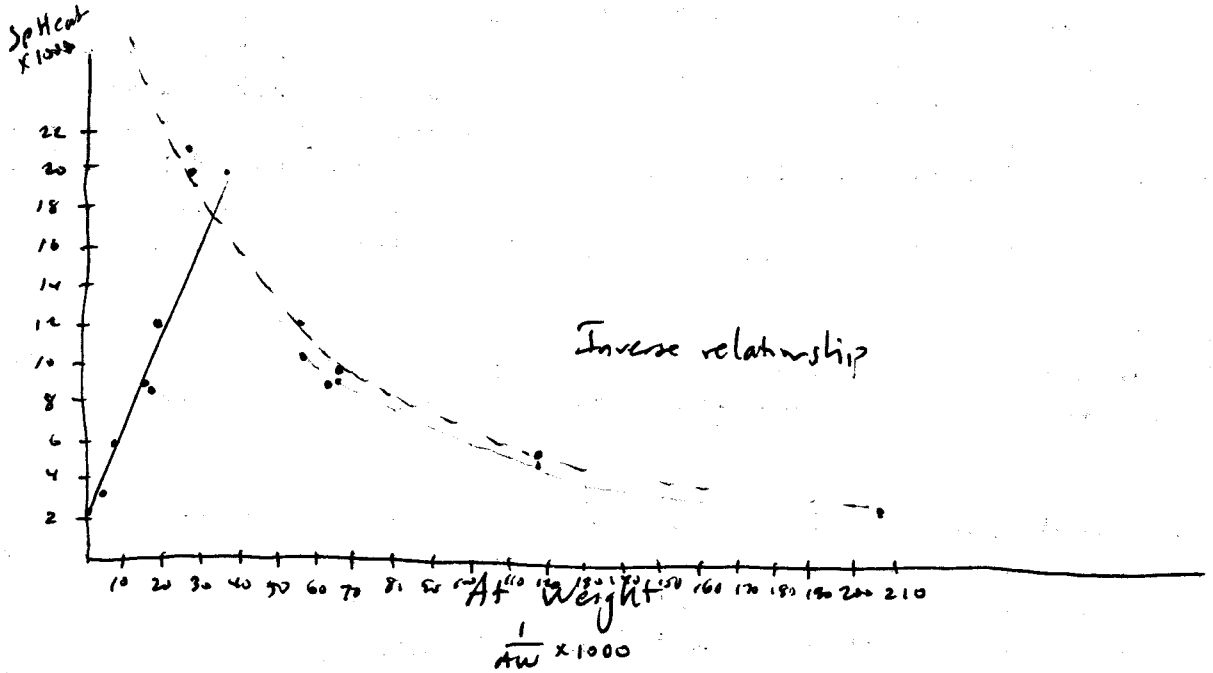
The temperature of the water bath did not appear to be uniform. An incorrect temperature, high or low, would change the value of the specific heat capacity of the metal in an inverse fashion, i.e. too high would make the specific heat capacity lower, too low would make it higher value.

No matter how fast the transfer of the metal into the calorimeter, some heat will be lost to the air, causing the heat transfer to the water to be lower and likewise causing the specific heat to be of lower value.

## Summary

The class as a whole was successful in attaining precision of measurement, and our group was successful in attaining accuracy as well. In graphing the data, it was determined that the relationship of specific heat to atomic weight was an inverse relationship, as might be suspected from the units for specific heat, $cal/g \cdot ^\circ C$

Source of error: Incomplete transfer of water from volumetric flask
Variable temperatures within water bath
Heat loss during transfer from water bath to calorimeter




$\frac{1}{Atwt} =$ Fe = 0.018 Fe
Cu = 0.016
Pb = 0.0048
Al = 0.037
Sn = 0.0084
Zn = 0.015