SPECIFIC HEAT OF A BRICK MODEL WRITE UP

Aim: To determine experimentally the specific heat of a brick.

Equipment Required:

- styrofoam cup
- crushed brick pieces
- beaker
- electronic balance
- two thermometers
- oven

Procedure: Refer to the Lab Notes from page 33 of EP

Results:

Initial temperature of heated brick pieces	89.0 +/- 0.5 ^{o} C
Initial temperature of water in styrofoam cup	20.0 +/- 0.5 ^{o} C
Final temperature of water and brick pieces	25.0 +/- 0.5 ^{o} C
Temperature rise of water $\Delta T1$	5 +/- 1 ^{o} C
Temperature fall of brick pieces $\Delta T2$	64 +/- 1 ^{o} C
Mass of brick pieces	73.80 +/- 0.05 g (change to kg for calculations)
Mass of water in styrofoam cup	99.80 +/- 0.05 g (change to kg for calculations)
Specific heat of water	4180 J kg^{-1} K^{-1} (no uncertainty for this)

Calculations:

1. Calculations of $\Delta T1$ and $\Delta T2$

Since these involve subtraction we add the uncertainties

$\Delta T1$ = 25 – 20 = 5 ºC uncertainties 0.5 + 0.5 = 1 ºC
$\Delta T2$ = 89 – 25 = 64 ºC uncertainties 0.5 + 0.5 = 1 ºC

2. Change these uncertainties to % errors

Water

% error in $\Delta T1$ = 1 x 100/5 = 20.0 %

Brick

% error in $\Delta T2$ = 1 x 100/64 = 1.56 %

3. Change the uncertainties in mass to % errors

% error in mass of brick pieces = 0.05 x 100/73.80 = 0.07 %

% error in mass of water = 0.05 x 100/99.80 = 0.05 %

4. Calculation of the specific heat of a brick

heat lost by the brick = heat gained by the styrofoam cup + heat gained by the water

$Q_{brick} = Q_{styrofoam\ cup} + Q_{water}$

Now the specific heat of the Styrofoam cup is negligible and can be considered to be zero and Therefore the equation becomes:

$Q_{brick} = Q_{water}$

$Q_{water} = m_{water}C_{water}\,\Delta T1$
$= 99.8 \times 10^{-3} \times 4.18 \times 10^{3} \times 5$
$= 2085.82$ J

since this involves multiplication % errors are added together
0.05 % + 0 % + 20.0 % = 20.05 %

Now

$$Q_{brick} = Q_{water}$$
$$m_{brick}C_{brick}\,\Delta T2 = Q_{water}$$
$$73.80 \times 10^{-3} \times C_{brick} \times 64 = 2085.82$$

since this involves multiplication and division % errors are added together
0.07 % + 1.56 % +20.05 % = 21.68 %

$$C_{brick} = 441.6 \text{ J kg}^{-1}\text{ K}^{-1} \quad +/- \quad 21.68\ \%$$

Change % error into an absolute error

Error = 21.68 x 441.6/100 = 95.7 J kg^{-1} K^{-1}

Therefore C_{brick} = 441.6 +/- 95.7 J kg^{-1} K^{-1}

Using the appropriate significant figures : C_{brick} = 400 +/- 100 J kg^{-1} K^{-1}

Evaluation

The accepted value for the specific heat of bricks (depending upon what they are made of) is in the range of 700 to 1000 J kg^{-1} K^{-1}

Clearly the results determined here are outside this range. This means there was another factor in play. This is heat lost to the environment during the heat transfer process. This can be shown by assuming the final temperature was 26.0 ºC instead of 25.0 ºC. Repeating the calculation C_{brick} becomes 538 J kg^{-1} K^{-1}. It would be easy to lose enough heat to the environment to reduce the final temperature by 1 or 2 ºC

Clearly a change of method is needed to reduce this effect.

Questions

1. When we compare the specific heats of various substances we see that the specific heat of a brick at 850 J $Kg^{-1}K^{-1}$ is of a medium to high value. Metals such as copper C = 390 J kg^{-1} K^{-1} are low to moderate and water C = 4180 J kg^{-1} K^{-1} is high. (2 marks total 1 for quoting the values and 1 for describing the range of specific heats)

2. Brick homes heat up and cool slowly because they have a medium to high specific heat. They can absorb a fair amount of heat with only a small temperature rise. Likewise they give off a fair amount of heat with only a small temperature fall. (1 mark total)

3. There are several reasons for the observed rates of heating and cooling of brick houses:

- porosity of the bricks
- colour of the bricks
- location of the house
- double or single brick walls
- orientation of house
- type of roof on house
- shades and curtains
- garden and trees

(2 marks - any four reasonable answers half a mark each)

4. The brick was broken into smaller pieces to increase the surface area of the brick in contact with the water (1 mark). This will allow for faster (1 mark) and more efficient heat transfer meaning there is less heat lost to the environment (1 mark) (3 marks total)

5. When the brick particles were added to the water, the water rose a small amount (1 mark) This was because the water was filling the air pockets in the bricks. The bricks were porous or had air cavities in them. (1 mark) (2 marks total)

6. It would not be an advantage to build brivk houses where high temperatures occur for long periods of time (1 mark) The house would heat up and remain hot as there was no way for the house to cool down. (1 mark) (2 marks total)

Conclusion:

In this experiment the specific heat was determined to be 400 +/- 100 J kg^{-1} K^{-1}. Given the accepted specific heat of bricks is in the vicinity of 700 – 900 J kg^{-1} K^{-1} and the specific heat that was determined outsdie this range, the experiment was unsuccessful. The greatest source of error in the experiment was heat lost to the environment when transferring the bricks into the cup.