Calorimetry Experiments Lagging Technology

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In spite of availability of sensitive and sophisticated temperature monitoring devices simple lab experiments on heat have been devoid of use of advancement in technology in most places. This is true for calorimetry experiments involving determination of specific heat, latent heat of fusion or vaporization, or heat of neutralization, etc. done in introductory physics or physical science courses.

Plastic/Styrofoam calorimeters are used to replace double-walled metallic ones. Mercury/alcohol glass thermometers or bulky probes are still used in monitoring temperatures at different steps. Very obviously, these devices absorb heat from the samples (or give out heat to the sample) to come to equilibrium thus giving erroneous measurements of the original temperature of the sample. It has rarely been mentioned in any physics/physical science text or lab manual to consider this loss of heat to or from the samples for calorimetric calculations. Quantity of heat transfer from sample to the thermometer will depend on how high the sample temperature is above the room temperature. Amount of sample and its temperature elevation above the ambient would determine the loss of heat to thermometer resulting in lower sample temperature than its actual thermal reading. Similarly, heat transfer from thermometer to the sample at temperature less than the ambient may or may not be significant.

Considering a small water sample at a very high temperature above the room temperature, an analysis[1] done earlier indicated that an ordinary inexpensive alcohol-glass thermometer commonly used in classrooms, requires about 342 cal to raise its temperature from room to 80o C. This means that the thermometer would read the temperature of a 100 g sample of water to be about 76.6oC, i.e. about 3.4oC less than 80oC. This study further revealed that it would take 228 g of water to show that an equilibrium temperature displayed by a glass thermometer could be a good approximation of the initial temperature of the water sample (within 0.5o C) when actual sample temperature was 80oC. This is assuming that the thermometer wasat room temperature, and only one-third of the thermometer was in contact with the sample. Because of low thermal conductivity of glass and the contact time of the thermometer being small (a minute or so), not much heat is conducted to the rest of the thermometer. The study also showed that heat loss from the Styrofoam calorimeter was quite significant. Then there could be problem with seeing temperature measurement if alcohollevel is below the lid.

Tiny (beaded thermocouple) thermistors with single strand leads can reduce heat loss significantly because of their size as well as ease in getting insulation from holes through which the leads come out. They would take much less time and energy to come to equilibrium with the sample. Infrared temperature measuring probe can provide instant and accurate temperature of the hot surface of an object for experiments used in determination of specific heat of metals. This will take out the guess work/assumption that hot metal is or is not at 100oC when it is being heated in a test tube dipping in boiling water or by suspension in steam. Digital lab thermometers calibrated to 0.1oC also seem to give a better approximation of the original temperature of a sample. Real time temperature determination can reduce errors in calorimetric calculations considerably. Of, course use of conventional temperature monitoring devices for calibration purposes cannot be ignored. So the devices must be calibrated before use.

[1] Gash, P., 2002. So you though a glass thermometer measured temperature. The Physics Teacher. 40:74-76.

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