

## Specific Heat of Copper, Introduction, equations needed

In the manual you are given an equation that is easily solved to give you a working equation:

$$\bar{c}_{cu} = \frac{(\bar{m}_w \bar{c}_w + \bar{m}_{Al} \bar{c}_{Al}) \Delta \bar{T}_w}{\bar{m}_{cu} \Delta \bar{T}_{cu}}$$

Since all the quantities on the right are not measured or given, we need the additional equations:

$$\begin{array}{ll} \bar{m}_w = \bar{m}_{Al+w} - \bar{m}_{Al} & \Delta m_w = \Delta m_{Al+w} + \Delta m_{Al} \\ \bar{m}_{Cu} = \bar{m}_{Cu+D} - \bar{m}_D & \Delta m_{Cu} = \Delta m_{Cu+D} + \Delta m_D \\ \Delta \bar{T}_{Cu} = \bar{T}_{HCu} - \bar{T}_{eq} & \Delta \Delta T_{Cu} = \Delta T_{HCu} + \Delta T_{eq} \\ \Delta \bar{T}_w = \bar{T}_{eq} - \bar{T}_{cw} & \Delta \Delta T_w = \Delta T_{eq} + \Delta T_{cw} \end{array} \quad \text{with uncertainty equations:}$$

Of course, all the variables and subscripts must be defined.

The working equation for the specific heat of copper can be calculated directly, of course, but the problem is that the uncertainty equation would be ugly. However, if the specific heat equation looked like this:

$$\bar{c}_{cu} = \frac{\bar{A} \Delta \bar{T}_w}{\bar{m}_{cu} \Delta \bar{T}_{cu}} \quad \text{then} \quad \Delta c_{cu} = \bar{c}_{cu} \left( \frac{\Delta A}{\bar{A}} + \frac{\Delta m_{cu}}{\bar{m}_{cu}} + \frac{\Delta \Delta T_w}{\Delta \bar{T}_w} + \frac{\Delta \Delta T_{cu}}{\Delta \bar{T}_{cu}} \right)$$

where we have defined a substitution variable:

$$A \equiv m_w c_w + m_{Al} c_{Al}$$

Again, this is ugly. If, instead, the equation for A was:

$$A = \bar{B} + \bar{D} \quad \text{then} \quad \Delta A = \Delta B + \Delta D$$

where we have defined the substitution variables:

$$B \equiv m_w c_w \quad D \equiv m_{Al} c_{Al}$$

with matching uncertainties:

$$\Delta B = \bar{B} \left( \frac{\Delta m_w}{\bar{m}_w} + \frac{\Delta c_w}{\bar{c}_w} \right) \quad \text{and} \quad \Delta D = \bar{D} \left( \frac{\Delta m_{Al}}{\bar{m}_{Al}} + \frac{\Delta c_{Al}}{\bar{c}_{Al}} \right)$$

Note that the equations for  $\bar{B}$ ,  $\Delta B$ , and  $\bar{D}$ ,  $\Delta D$  could be substituted back into the equations for A and  $\Delta A$ . These could then be substituted back into the equations for  $\bar{c}_{Cu}$ ,  $\Delta c_{Cu}$  giving only one equation for  $\bar{c}_{Cu}$  and one for  $\Delta c_{Cu}$ . Try this if you like, but it would be ugly. One equation is not necessary better or more clear than a set of equations.