Specific Heat Pre-Lab

Use this worksheet to calculate the value of specific heat value based on the given pre-lab data. This sheet will help you keep track of the uncertainty. Answer the questions from the pre-lab in your notebook. We will use the notation: subscript c for "cup", subscript s for "stir rod", subscript a for "aluminum", subscript b for the metal block, and subscript w for the water.

In lab, you are to calculate the specific heat, c_b:

$$c_b = \frac{m_a c_a (T_f - T_{ia}) + m_w c_w (T_f - T_{iw})}{-m_b (T_f - T_{ib})}$$

We will consider a careful examination of the "error analysis" based on the **measurements** provided: (The measured data has been entered. You should fill in the relative uncertainty.)

$m_c =$	60.0	$\pm$ .1	g	$\frac{.1\,\text{g}}{60.0\,\text{g}} = 0.17\%$
$m_s =$	3.2	$\pm$ .1	g	3.1%
$m_a = m_c + m_s =$	63.2	$\pm$ .1	g	.16%
$m_w + m_a =$	152.3	$\pm$ .1	g	0.066%
$m_b =$	74.8	$\pm$ .1	g	.13%
$T_{ia} = T_{iw} =$	22.3	$\pm$ .1	°C	.45%
$T_{ib} =$	99.4	$\pm$ .1	°C	.10%
$T_f =$	27.0	$\pm$ .1	°C	.37%
$c_a =$	0.91	$\pm$ .01	kJ/kg·K	1.1%
$c_w =$	4.186	$\pm$ .001	kJ/kg·K	.024%

When you add or subtract, then add the uncertainties (and then find the relative uncertainty). When you multiply or divide, then add the relative uncertainties (and then find the uncertainty).

To get a value for c, we need the numerator, $Q_w + Q_a$, and the denominator, $m_b \Delta T_b$. For the numerator, we need Q_w and Q_a. To get Q_w we need m_w and ΔT_w because we have a value for c_w. To get Q_a, we have m_a and c_a, and we need ΔT_a. For the denominator, we have m_b and need ΔT_b.

$m_w = m_{\text{a+w}} - m_a =$	89.1	$\pm$ .2	g	.22%	$\delta m_w = \delta m_{(a+w)} + \delta m_a$
$\Delta T_a = \Delta T_w =$	4.7	$\pm$ .2	°C	4.26%	$\delta \Delta T = \delta T_f + \delta T_i$
$\Delta T_b =$	-72.4	$\pm$ .2	°C	.276%	$\delta \Delta T = \delta T_f + \delta T_i$

For the numerator, then

$$Q_w = m_w c_w (T_f - T_{iw}) = \; 1753 \quad \pm 79 \quad \text{J} \quad 4.5\% \qquad \frac{\delta Q}{Q} = \frac{\delta m_w}{m_w} + \frac{\delta c}{c} + \frac{\delta(\Delta T)}{(\Delta T)}$$

$$Q_a = m_a c_a (T_f - T_{ia}) = \; 270 \quad \pm 15 \quad \text{J} \quad 5.5\% \qquad \frac{\delta Q}{Q} = \frac{\delta m_a}{m_a} + \frac{\delta c}{c} + \frac{\delta(\Delta T)}{(\Delta T)}$$

$$Q_w + Q_a = \; 2023 \quad \pm 94 \quad \text{J} \quad 4.7\% \qquad \delta(\text{numerator}) = \delta Q_w + \delta Q_a$$

and for the denominator,

$$m_b (T_f - T_{ib}) = \; 5416 \quad \pm 22 \quad \text{g} \cdot \text{K} \quad .41\% \qquad \frac{\delta(m_b \, \Delta T)}{(m_b \, \Delta T)} = \frac{\delta m_b}{m_b} + \frac{\delta(\Delta T)}{(\Delta T)}$$

Therefore:

$$c_b = \frac{Q_w + Q_a}{-m_b (T_f - T_{ib})} = \; .374 \quad \pm .019 \quad \text{kJ/kg·K} \quad 5.1\% \qquad \frac{\delta c}{c} = \frac{\delta(\text{numerator})}{(\text{numerator})} + \frac{\delta(m_b \, \Delta T)}{(m_b \, \Delta T)}$$

Specific Heat Worksheet for Your Results

Use this worksheet to calculate your specific heat value based on your measured data. This sheet will help you keep track of the uncertainty and the questions from the pre-lab exercise should help you write your analysis. We will use the notation: subscript c for "cup", subscript s for "stir rod", subscript a for "aluminum", subscript b for the metal block, and subscript w for the water.

In lab, you are to calculate the specific heat, c_b:

$$c_b = \frac{m_a c_a (T_f - T_{ia}) + m_w c_w (T_f - T_{iw})}{-m_b (T_f - T_{ib})}$$

We will consider a careful examination of the "error analysis" based on the **measurements** provided:

$m_c =$	_____	$\pm$	_____	g	_____
$m_s =$	_____	$\pm$	_____	g	_____
$m_c + m_s =$	_____	$\pm$	_____	g	_____
$m_w + m_c =$	_____	$\pm$	_____	g	_____
$m_b =$	_____	$\pm$	_____	g	_____
$T_{iw} =$	_____	$\pm$	_____	°C	_____
$T_{ib} =$	_____	$\pm$	_____	°C	_____
$T_f =$	_____	$\pm$	_____	°C	_____
$c_a =$	_____	$\pm$	_____	kJ/kg·K	_____
$c_w =$	_____	$\pm$	_____	kJ/kg·K	_____

When you add or subtract numbers, you should add the uncertainties (and then find the relative uncertainty). When you multiply or divide numbers, you should add the relative uncertainties (and then find the uncertainty).

To get a value for c, we need the numerator, $Q_w + Q_a$, and the denominator, $m_b \Delta T_b$. For the numerator, we need Q_w and Q_a. To get Q_w we need m_w and ΔT_w because we have a value for c_w. To get Q_a, we have m_a and c_a, and we need ΔT_a. For the denominator, we have m_b and need ΔT_b.

$m_w = m_{\text{cup+water}} - m_c =$	_____	$\pm$	_____	g	_____	$\delta m_w = \delta m_{(c+w)} + \delta m_c$
$\Delta T_w =$	_____	$\pm$	_____	°C	_____	$\delta \Delta T = \delta T_f + \delta T_i$
$\Delta T_b =$	_____	$\pm$	_____	°C	_____	$\delta \Delta T = \delta T_f + \delta T_i$

For the numerator, then

$Q_w = m_w c_w (T_f - T_{iw}) =$	_____	$\pm$	_____	J	_____	$\frac{\delta Q}{Q} = \frac{\delta m_w}{m_w} + \frac{\delta c}{c} + \frac{\delta(\Delta T)}{(\Delta T)}$
$Q_a = m_a c_a (T_f - T_{ia}) =$	_____	$\pm$	_____	J	_____	$\frac{\delta Q}{Q} = \frac{\delta m_a}{m_a} + \frac{\delta c}{c} + \frac{\delta(\Delta T)}{(\Delta T)}$
$Q_w + Q_a =$	_____	$\pm$	_____	J	_____	$\delta(\text{numerator}) = \delta Q_w + \delta Q_a$

and for the denominator,

$m_b (T_f - T_{ib}) =$	_____	$\pm$	_____	g · K	_____	$\frac{\delta(m_b \Delta T)}{(m_b \Delta T)} = \frac{\delta m_b}{m_b} + \frac{\delta(\Delta T)}{(\Delta T)}$

Therefore:

$c_b = \frac{Q_w + Q_a}{-m_b (T_f - T_{ib})} =$	_____	$\pm$	_____	kJ/kg·K	_____	$\frac{\delta c}{c} = \frac{\delta(\text{numerator})}{(\text{numerator})} + \frac{\delta(m_b \Delta T)}{(m_b \Delta T)}$