Name : ______________________ **(   )** **Class :** _____ **Date :** _________

Experiment No.: **1** **Duration: 1 hr**

Worksheet Title: **Specific Heat Capacity of Brass**

Aim : In this experiment, you are to determine a value for the specific heat capacity of brass.

Apparatus :

To be shared:
1 x 500 ml beaker with wire gauze at the base of beaker
1 x bunsen burner, tripod, lighter and wire gauze
1 x thermometer (range -10 to 100 degrees celsius)
1 x glass rod
4 x 100 g brass weight

Individual:
1 x 250 ml beaker
1 x 250 ml expanded polystrene cup
1 x pair of tongs
1 x ceramic tiles
1 x 100 ml measuring cylinder
1 x thermometer
1 x glass rod

(a) (i) Heat some water in the large 500 cm^3 beaker and maintain the water at its boiling point.

(ii) Immerse the 100 g brass weights into the boiling water.

(iii) Measure and record the constant temperature of the brass weights in the boiling water, T_b.

T_b = ...100.0°C......

(iv) Assuming that water has a density of 1.00 g cm^{-3}, measure, using the measuring cylinder, 40 g of water at room temperature and pour the water into the polystyrene cup (note that 1 cm^{-3} = 1 ml). Record the mass m_w as well as the temperature T_r of this water.

m_w = ...40.0 g......

T_r = ...29.0 °C...... [1]

(v) As quickly as possible, transfer the one hot brass weight from the boiling water to the water in the polystyrene cup.

(vi) Measure and record the highest temperature, T_f reached by the water in the cup.

T_{f1} = 42.0 ℃
T_{f2} = 42.0 ℃
Average $<T_f> = \frac{T_{f1}+T_{f2}}{2} = \frac{42.0+42.0}{2} = 42.0$℃

T_f = ...42.0 °C...... [1]

(b) Change the mass of water m_w at room temperature and repeat steps (a)(ii) to (a)(vi) until you have 6 sets of values for m_w and T_f.

m_w / g	T_r / °C	T_{f1} / °C	T_{f2} / °C	$<T_f>$/ °C	$\frac{1}{m_w}$ / g^{-1}	$\frac{T_f - T_r}{T_b - T_f}$
40.0	29.0	42.0	42.0	42.0	0.0250	0.224
50.0	29.0	39.8	39.7	39.8	0.0200	0.179
60.0	29.0	38.2	38.1	38.2	0.0167	0.149
70.0	29.0	37.1	37.2	37.2	0.0143	0.131
80.0	29.0	36.1	36.1	36.1	0.0125	0.111
90.0	29.0	35.5	35.4	35.5	0.0111	0.101

[7]

(c) By assuming that all heat lost by the brass weight is absorbed by the water in the cup, it is suggested that the following equation will relate T_b, T_r and T_f :

$$m_w c_w (T_f - T_r) = m_b c_b (T_b - T_f)$$

where m_w and c_w are respectively the mass and specific heat capacity of the water in the cup. m_b and c_b are the mass and specific heat capacity of the brass weight.

Plot a suitable graph to determine <u>if your data supports the above equations.</u>

Given $m_w c_w (T_f - T_r) = m_b c_b (T_b - T_f)$

$$\frac{(T_f - T_r)}{(T_b - T_f)} = \frac{m_b c_b}{c_w}\left(\frac{1}{m_w}\right)$$

By plotting a graph of $\frac{(T_f - T_r)}{(T_b - T_f)}$ against $\left(\frac{1}{m_w}\right)$, a straight line graph should be obtained with gradient $\frac{m_b c_b}{c_w}$ and y-intercept 0.

<u>For Best Fit Line</u>

Using points on best fit line, (0.0260, 0.232) and (0.0120, 0.108),
gradient of best fit line = $\frac{0.232-0.108}{0.0260-0.0120}$ = 8.86 g (3 s.f. follow raw data)

y-intercept of best fit line = 0.232 – (8.86)(0.0260) = 0.00164 (3 s.f. follow raw data)

<u>For Extreme Fit Line</u>

Using points on extreme fit line, (0.0254, 0.220) and (0.0130, 0.120),
gradient of extreme fit line = $\frac{0.220-0.120}{0.0254-0.0130}$ = 8.06 g (3 s.f. follow raw data)

y-intercept of extreme fit line = 0.220 – (8.06)(0.0254) = 0.0153 (3 s.f. follow raw data)

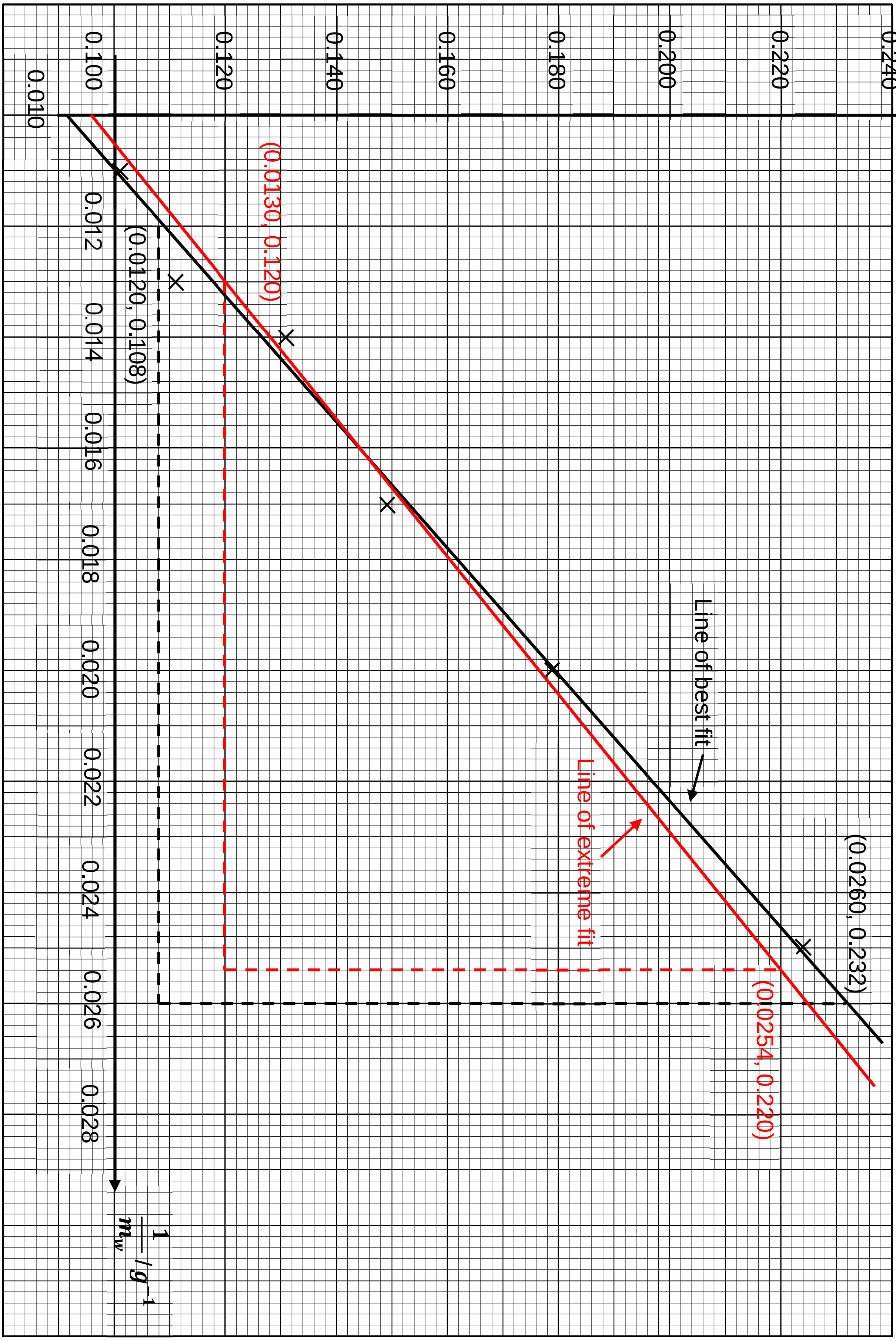
[2]

Hence, uncertainty in y- intercept = ±|0.00164 – 0.0153| = ±0.01 (1 s.f.)

Thus *y*-intercept = (0.00 ± 0.01)

Theoretically, if the above equation is true, the y-intercept of the best fit line should fall near 0. Since the y-intercept of the best fit line falls in the range of 0.00 ± 0.01, the above relationship is most probably valid.

Graph of $\frac{(T_f - T_r)}{(T_b - T_f)}$ against $\frac{1}{m_w}$ / g^{-1}



[3]

(d) Comment on any anomalous data or results that you may have been obtained.

There is no anomalous point as all the data points lie close to and are evenly scattered about the line of best fit.

(e) Determine the specific heat capacity c_b of the brass weight. Include its appropriate unit. (Take the specific heat capacity of water c_w to be 4.20 J g^{-1} K^{-1})

From the best fit line of $\frac{(T_f - T_r)}{(T_b - T_f)}$ against $\frac{1}{m_w}$, $\frac{m_b c_b}{c_w}$ would be given by its gradient.

$$gradient\ of\ best\ fit\ line = \frac{m_b c_b}{c_w} = 8.86$$

$$c_b = \frac{(8.86)(4.20)}{100} = 0.372\ \mathrm{J\,g^{-1}\,K^{-1}}$$

(f) Estimate the uncertainty for the value of c_b that you have obtained in (e).

From the extreme line graph of $\frac{(T_f - T_r)}{(T_b - T_f)}$ against $\frac{1}{m_w}$, $\frac{m_b c_b}{c_w}$ would be given by its gradient.

$$gradient\ of\ extreme\ fit\ line = \frac{m_b c_b}{c_w} = 8.1$$

$$c_b' = \frac{(8.06)(4.20)}{100} = 0.339\ \mathrm{J\,g^{-1}\,K^{-1}}$$

Hence,

$$\begin{aligned} \Delta c_b &= \pm|c_b - c_b'| \\ &= \pm|0.372 - 0.339| \\ &= \pm 0.03 \end{aligned}$$

(g) State one significant source of error that contributed to the uncertainty in this experiment.

1) In the process of transferring the brass mass from the beaker to the polystyrene cup, water from the beaker may be transferred over as well, causing systematic errors in T_f recorded.
2) The brass mass provided may not necessarily be of the mass required, causing incorrect values of c_b to be calculated.

(h) Suggest improvements that could be made to the experiment to address the errors identified in (g). You may suggest the use of other apparatus or a different procedure.

1) The brass mass could be heated in an oven.

2) Measure and record the value of m_b using an electronic pan balance.