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Prelab 1

a) m_1 of H_2O @ T_1 mixed with m_2 of H_2O @ T_2. Find T_f

We know $\Delta Q = mc\Delta T$, so we can create two equations:

$\Delta Q_1 = m_1 c(T_f - T_1)$; $\Delta Q_2 = m_2 c(T_2 - T_f)$; $\Delta Q_1 = \Delta Q_2 = \Delta Q$

$$m_1 \cancel{c}(T_f - T_1) = m_2 \cancel{c}(T_2 - T_f)$$

$$T_f m_1 - T_1 m_1 - T_2 m_2 + T_f m_2 = T_f(m_1 + m_2) - T_1 m_1 - T_2 m_2 = 0$$

$$T_f = \frac{T_1 m_1 + T_2 m_2}{m_1 + m_2}$$

b) m_ω of $H_2O(l)$ @ T_ω mixed with m_{ice} of $H_2O(s)$ @ $0°C$. Find T_f

We know heat from one goes into the other: $\Delta Q_1 = \Delta Q_2 = \Delta Q$

For heating water, $\Delta Q = mc\Delta T$. For melting ice, $\Delta Q = mL_f$

$$m_\omega c(T_\omega - T_f) = m_{ic} c(T_f \cancel{-0}) + m_{ic} L_f$$

$$m_\omega c T_\omega - m_\omega c T_f = m_{ic} c T_f + m_{ic} L_f$$

$$m_\omega c T_\omega - m_{ic} L_f = T_f(m_{ic} c + m_\omega c)$$

$$\Rightarrow T_f = \frac{m_\omega c T_\omega - m_{ic} L_f}{m_{ic} c + m_\omega c}$$

c) Find $L_f(c_\omega)$.

From (b): $m_\omega c T_\omega - m_\omega c T_f = m_{ic} c T_f + m_{ic} L_f$

$$m_{ic} L_f + c(m_{ic} T_f + m_\omega T_f - m_\omega T_\omega) = 0$$

$$L_f = \frac{c(m_\omega T_\omega - m_{ic} T_f - m_\omega T_f)}{m_{ic}}$$

(d) Without ice starting at 0, T_{ic} doesn't go away, so

$$L_f = \frac{c(m_\omega T_\omega - m_{ic} T_f - m_\omega T_f + m_{ic} T_{ic})}{m_{ic}}$$

$$= \frac{c(m_\omega T_\omega - m_{ic} T_f - m_\omega T_f)}{m_{ic}} + \frac{\cancel{m_{ic}} T_{ic} \cdot c}{\cancel{m_{ic}}}$$

$$\alpha_{L_f} = \sqrt{\alpha_{T_{ic}}^2 \cdot \left(\frac{\partial L_f}{\partial T_{ic}}\right)^2} = \alpha_{T_{ic}} \cdot c = 2°C \cdot 0.49 \frac{cal}{g°C}$$

$$= 0.98 \frac{cal}{g}$$

So it'll be ± 0.98 basically, assuming other quantities have no errors.

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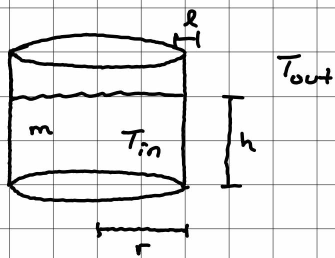
Prelab 2



$$\vec{q} = -k \vec{\nabla} T$$

$$H = -kA \frac{\partial T}{\partial x} = -kA \frac{T_1 - T_0}{l}$$

$$\frac{\partial T}{\partial t} = \frac{k}{\rho c} \frac{\partial^2 T}{\partial x^2}$$

(a) $H = -kA \cdot \frac{T_{out} - T_{in}}{l} = -k \left[2\pi r h + \pi r^2 \right] \frac{T_{out} - T_{in}}{l}$

rate of heat flow out of the chamber

(b) temp change is $\frac{dT_{in}}{dt}$. $\frac{dQ}{dt} = \frac{d}{dt} mc\Delta T = mc \frac{dT_{in}}{dt}$

$$H = -kA \frac{T_{out} - T_{in}}{l} = mc \frac{dT_{in}}{dt} = -k \left[2\pi r h + \pi r^2 \right] \frac{T_{out} - T_{in}}{l}$$

$$\Rightarrow \quad k = \frac{-mcl \cdot \frac{dT_{in}}{dt}}{(2\pi r h + \pi r^2)(T_{out} - T_{in})}$$

Prelab 3

Just reading...

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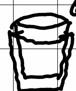
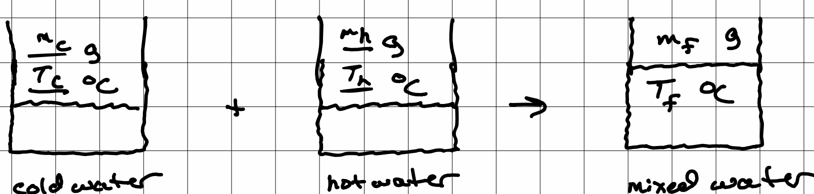
Experiment 1

We want to mix two different samples of water, at different temperatures. We will know the initial masses and temps of the water. We will mix them, then measure the temperature continuously until they reach equilibrium.



two nested styrofoam cups contain water
fill each one 1/3 full for max mass, to minimize errors. nested cups minimize heat loss outside of system

Stacked cups have mass of 10g when empty



	g			°C		
Trial	m_c	m_h	m_f	T_c	T_h	T_f
1	202±1	230±1	430±1	0.2±0.1	45.3±0.1	24.4±0.1
2	181±1	132±1	310±1	0.2±0.1	45.0±0.1	18.9±0.1
3	275±1	116±1	390±1	1.2±0.1	45.0±0.1	14.1±0.1
4	127±1	288±1	412±1	1.3±0.1	45.7±0.1	32.7±0.1

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Experiment 1

Equipment
- 2x 2x 10g styrofoam cup
- tap water, distilled water
- ice
- Shelolab water heater
- mass scale
- water pitches
- Logger Pro software
- Labquest mini
- Vernier temp probe

Procedure:
Heat water in bath to 50°C
Obtain ice and water in pitcher, wait for them to cool to 0°C
Fill one cup w/ cold water 1/3 of way, determine mass
Fill second cup w/ hot water 1/3 of way, find mass
(no ice)
mix cups, observe probe reading on logger pro
once equilibrium, record temp, record mass

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Experiment 2

Equipment:
- tub of ice
- shelolab water heater
- mass scale
- temperatrue probe
- logger pro software
- 2x 2x styrofoam cups
- labquest mini

Procedure

collect ice in one cup, measure mass + temp
collect hot water in other cup, measure mass + temp
mix, wait for equilibrium, measure mass and temperature

$$m_h \cdot C \cdot \Delta T_h = m_c \cdot C \cdot \Delta T_c + m_c \cdot L$$

✓ ✓ ✓ ✓ ✓ ✓ ✓

cooling = heating + melting

$$L = \frac{c\left[m_h(T_f - T_h) - m_c(T_f - T_c)\right]}{m_c}$$

$$m_h c_w \Delta T_h = m_c \cdot c_w \cdot T_f + m_c \cdot L + m_c \cdot c_i \cdot -T_c$$

$$L = \frac{m_h c_w (T_f - T_h) - m_c c_w T_f - m_c c_i \cdot -T_c}{m_c}$$

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Experiment 2

	g			°C		
Trial	m_c	m_h	m_f	T_c	T_h	T_f
1	65±1	156±1	218±1	-1.3±0.1	46.0±0.1	10.7±0.1
2	71±1	175±1	243±1	-1.3±0.1	45.7±0.1	11.9±0.1
3	39±1	303±1	339±1	-1.0±0.1	45.6±0.1	33.0±0.1
4	124±1	117±1	263±1	-1.4±0.1	45.3±0.1	-0.1±0.1
		+31±1			+45.3±0.1	

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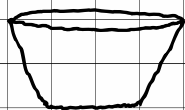
Experiment 3a

Current Ambient Temperature: $17.2 \pm 0.1°C$

Cup: 

Heat lost through base and sides
Thickness of base: 0.20 ± 0.01 cm
Thickness of sides: 0.19 ± 0.01 cm
Diameter of base: 5.6 ± 0.1 cm

Things to know: m, m^2, $\vec{\nabla} T$, ΔT, Δt

We have an ambient environment of known temperature:
heat bath
Put cold water in a styrofoam cup, measure mass and temp
We put cup in bath matching internal and external heights
We put probe in cup and record data with logger Pro
If we know how much the water in cup changes temp, we know how much it changes heat. We can look at this over time to find heat transfer/time as a function of ΔT.

Equipment
- shelolab water heater
- 2x 2x styrofoam cups
- mass scale
- temperatue probe
- labquest mini
- logger pro software

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Experiment 3a

Procedure:

We fill a styrofoam cup w/ tap water up to a height h, We place the temperature probe in the cup, then place the cup in the heat bath, holding it down against the bottom. We know the dimensions of the cup, so we can export data from logger pro to find heat flow.

Trial 1 (short) height: 5 ± 0.3 cm m_w = 121 ± 1 g

Trial 2 (long) height: 10.3 ± 0.3 cm m_w = 350 ± 1 g

T_{out} = 46.7°C

To measure the mass, we put it on the scale and subtracted the cup mass (5g). To measure height we held it to the light

Experiment 3c

We follow the same procedure as 3a, swapping the styrofoam cup for the metal can. Can mass: 45 ± 1 g

To measure water height we put our finger in, then measured the waterline.

$$mc_v \frac{dT}{dt} = \frac{kA}{l}(T_1 - T_0) \qquad mc \frac{d\Delta T}{dt} = \frac{kA}{l}\Delta T$$

$$\frac{d\Delta T}{dt} = \gamma \Delta T \Rightarrow \Delta T = \Delta T_0 e^{-\gamma t}$$

Trial 1 (short) m_w = 131 ± 1g h = 3.5 ± 0.3 cm

Trial 2 (long) m_w = 185 ± 1g h = 5.7 ± 0.3 cm

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Experiment 4