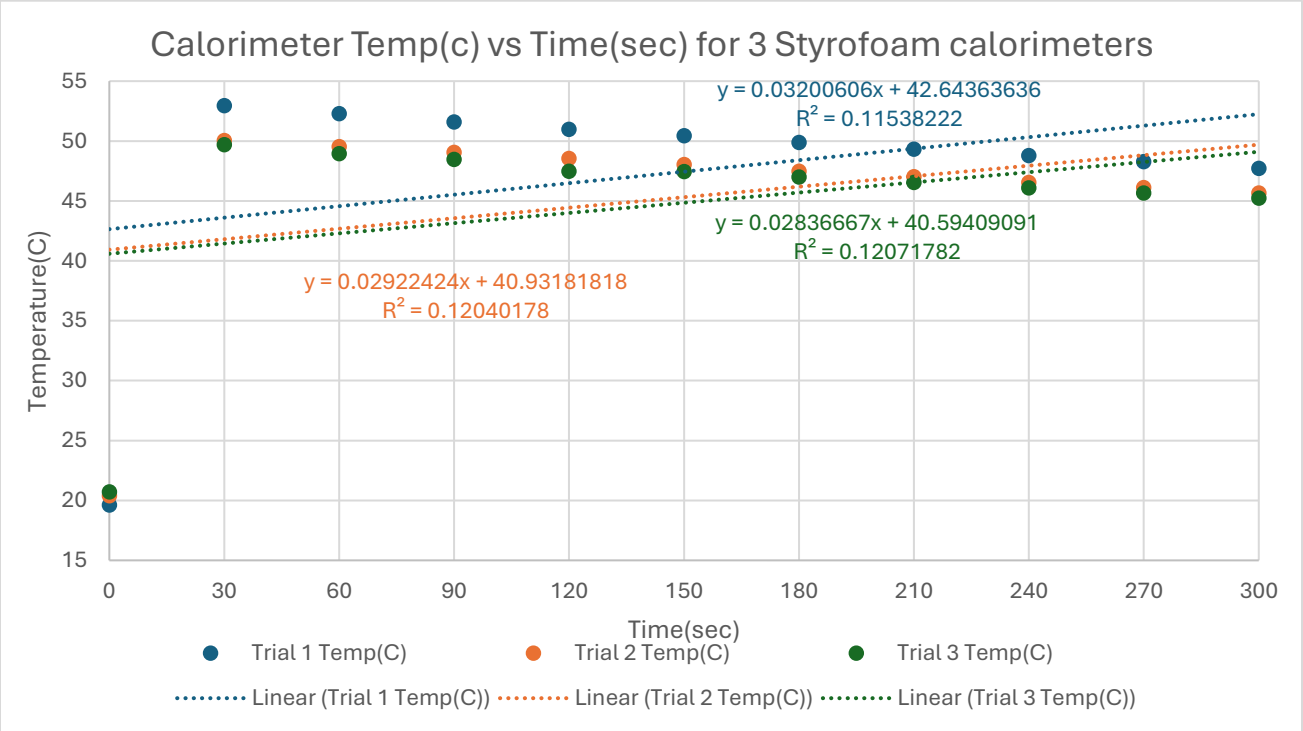
Determining Calorimeter Constants

1. Make a table of your data from part A.

Table 1. Time and Temps for 3 Trials of Styrofoam Cup Calorimeters

Time (Seconds)	Trial 1 Temp(C)	Trial 2 Temp(C)	Trial 3 Temp(C)
0	19.62	20.41	20.71
30	52.97	50.04	49.71
60	52.29	49.55	48.95
90	51.59	49.05	48.47
120	50.98	48.55	47.49
150	50.45	48.03	47.45
180	49.88	47.49	47.01
210	49.32	47.02	46.54
240	48.78	46.56	46.10
270	48.28	46.11	45.66
300	47.73	45.66	45.25

2. Create a plot of Temperature vs. Time from your part A data. This plot should include all 3 trials, and the trials should be clearly marked. Include the value for final temperature for each trial in the caption of this plot.



Graph 1. Cal. Temp vs Time for 3(With Initial Temp). Final Temp1=47.47C, Final Temp2=45.66C, Final Temp3=45.25

3. Show your entire calculation for the calorimeter constant for trial 1 from part A. Begin with a general formula and continue from there. Your smart worksheet guides you through this. You will only be asked to show this work once, so make sure it's correct.

Trial 1:

Qcal +Cwater*mcoldwater*deltaTcoldwater +Cwater*mhotwater*deltaThotwater = 0

CcalT = -Cwater*mcoldwater*deltaTcoldwater -Cwater*mhotwater*deltaThotwater

Qcal * (47.73-19.62) = -4.184(38.64)(47.73-19.62) – 4.184(49.28)(47.73-100)

Qcal = 222.4 J/C

4. What is the average calorimeter constant, and what is the standard deviation for your data from part A? You do not need to show your work for these questions, but if the values are incorrect there will be no partial credit.

Average = 276.8 J/C

Std. Dev = 47.21 J/C

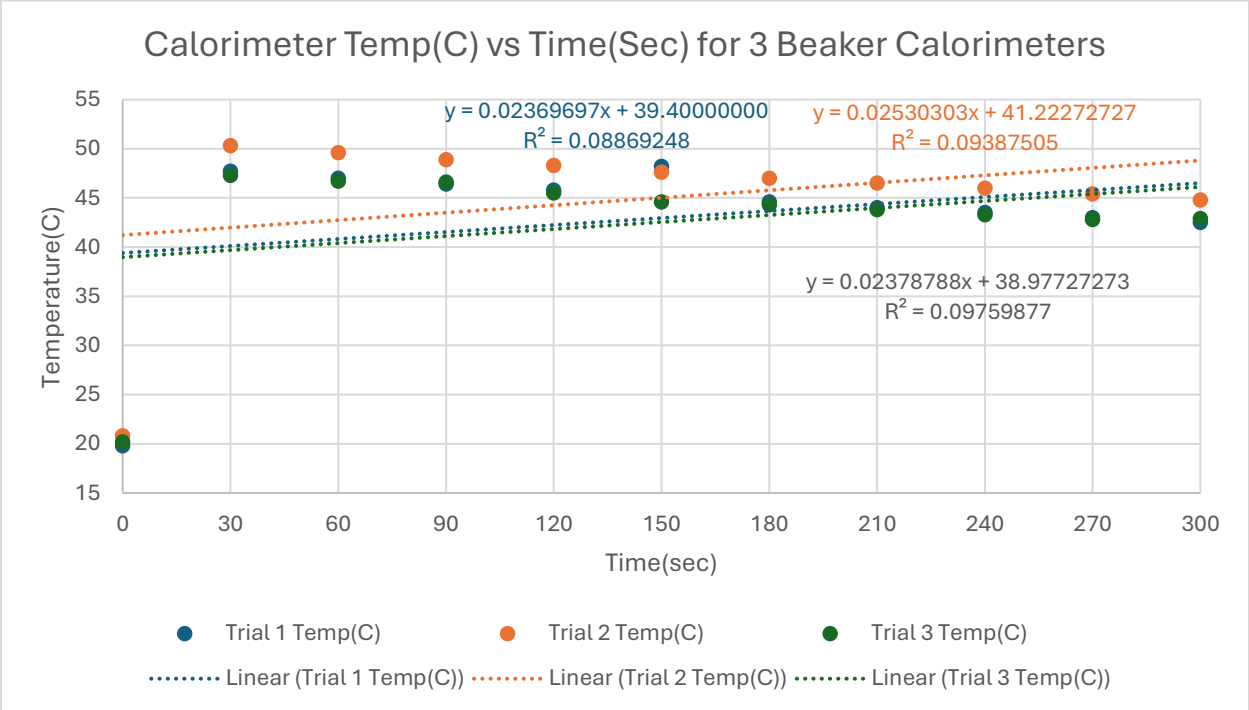
1. Scratch Work for Question 4:
2. Trial 2:
3. QcalT +cwater*mcoldwater*deltaTcoldwater +cwater*mhotwater*deltaThotwater = 0
4. QcalT = -cwater*mcoldwater*deltaTcoldwater -cwater*mhotwater*deltaThotwater
5. Qcal * (45.66-20.41) = -4.184(39.07)(45.66-20.41) – 4.184(51.48)(45.66-100)
6. Qcal = 300.97 J/C
7. Trial 3:
8. QcalT +cwater*mcoldwater*deltaTcoldwater +cwater*mhotwater*deltaThotwater = 0
9. QcalT = -cwater*mcoldwater*deltaTcoldwater -cwater*mhotwater*deltaThotwater
10. Qcal * (45.25-20.71) = -4.184(38.49)(45.25-20.71) – 4.184(50.28)(47.25-100)
11. Qcal = 307 J/C

5. Make a table of your data from part B.

Table 2. Time and Temps for 3 Trials of Beaker Calorimeters

Time (Seconds)	Trial 1 Temp(C)	Trial 2 Temp(C)	Trial 3 Temp(C)
0	19.8	20.8	20.2
30	47.7	50.3	47.3
60	47.0	49.6	46.7
90	46.4	48.9	46.6
120	45.8	48.3	45.5
150	48.2	47.6	44.6
180	44.6	47.0	44.3
210	44.0	46.5	43.8
240	43.5	46.0	43.3
270	43.0	45.4	42.8
300	42.5	44.8	42.9

6. Create a plot of Temperature vs. Time from your part B data. This plot should include all 3 trials, and the trials should be clearly marked. Include the value for final temperature for each trial in the caption of this plot.



Graph 2. Cal. Temp vs Time for 3(With Initial Temp). Final Temp1=42.5C, Final Temp2=44.8C, Final Temp3=42.9C

7. What is the average calorimeter constant, and what is the standard deviation for your data from part B?
   Trial 1:
   Qbeaker +Cwater*mcoldwater*deltaTcoldwater +Cwater*mhotwater*deltaThotwater = 0
   Cbeaker(42.5-19.8) = -4.184(38.61)(42.5-19.8) + -4.184(48.72)(42.5-100)
   C = 352.1 J/C

   Trial 2:
   Qbeaker +cwater*mcoldwater*deltaTcoldwater +cwater*mhotwater*deltaThotwater = 0
   Cbeaker(44.8-20.8) = -4.184(40.01)(44.8-20.8) + -4.184(49.44)(44.8-100)
   C = 308.37 J/C

   Trial 3:
   Qbeaker +cwater*mcoldwater*deltaTcoldwater +cwater*mhotwater*deltaThotwater = 0
   Cbeaker(42.9-20.2) = -4.184(39.57)(42.9-20.2) + -4.184(48.39)(42.9-100)
   C = 343.72 J/C

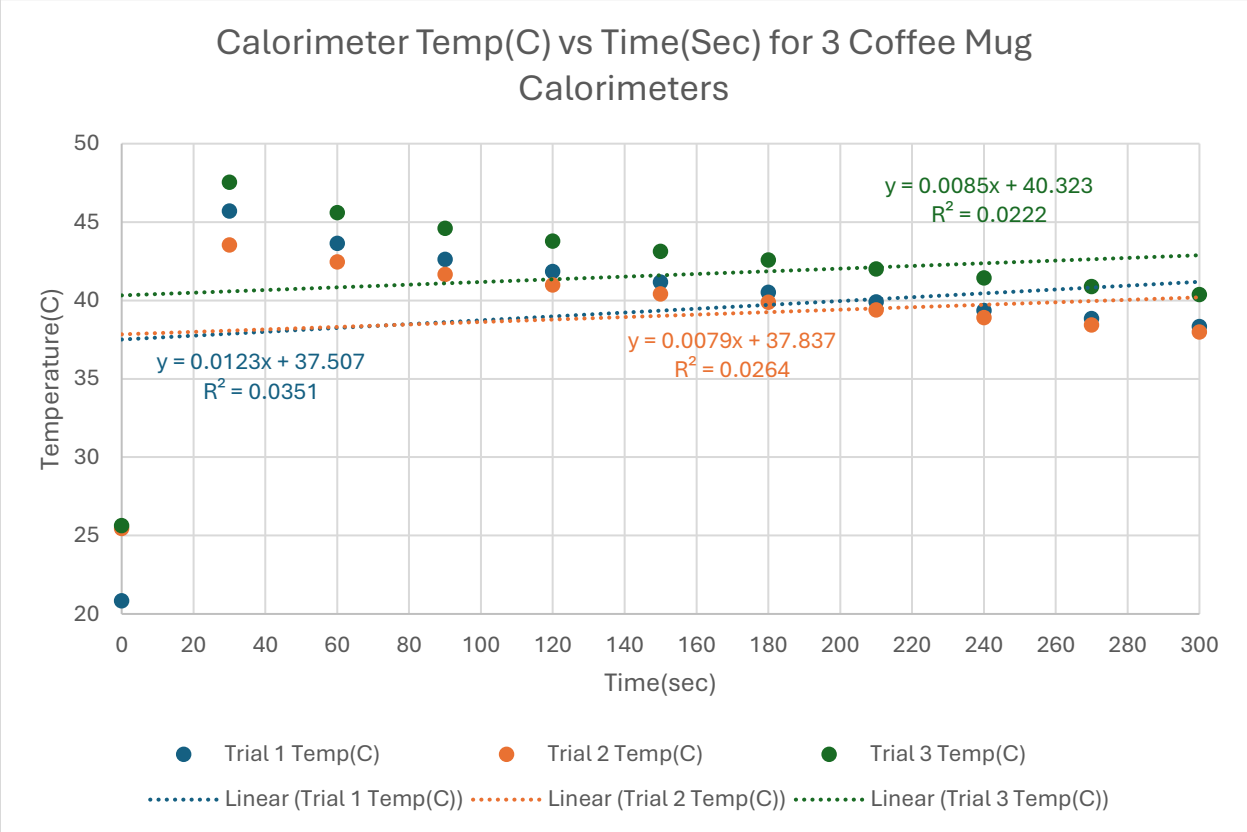
   Avg = 334.73
   Std. Dev = 23.21

8. Make a table of your data from part C.

Table 3. Time and Temps for 3 Trials of Coffee Mug Calorimeters

Time (Seconds)	Trial 1 Temp(C)	Trial 2 Temp(C)	Trial 3 Temp(C)
0	20.84	25.46	25.65
30	45.70	43.55	47.55
60	43.65	42.46	45.60
90	42.62	41.66	44.61
120	41.85	41.00	43.78
150	41.18	40.42	43.13
180	40.52	39.90	42.58
210	39.91	39.39	42.01
240	39.36	38.90	41.45
270	38.85	38.44	40.89
300	38.34	38.00	40.38

9. Create a plot of Temperature vs. Time from your part C data. This plot should include all 3 trials, and the trials should be clearly marked. Include the value for final temperature for each trial in the caption of this plot.



Graph 3. Cal. Temp vs Time for 3 Coffee Mug Calorimeters(With Initial Temp). Final Temp1=38.34 C, Final Temp2=38.00 C, Final Temp3=40.388 C

10. What is the average calorimeter constant, and what is the standard deviation for your data from part C?

Trial 1:

Qcoffeemug + Cwater*MColdwater*DeltaTcoldwater + Cwater*Mhotwater*DeltaThotwater = 0

Qcoffeemug = -Cwater*MColdwater*DeltaTcoldwater -Cwater*Mhotwater*DeltaThotwater

Ccoffemug(38.34-20.84) = -4.184(39.2)(38.34-20.84) – 4.184(48.93)(38.34-100)

Trial 2:

Ccoffemug(38.00-25.46) = -4.184(39.79)(38-25.46) – 4.184(49.41)(38-100)

Trial3:

Ccoffemug(40.38-25.65) = -4.184(39.21)(40.38-25.65) – 4.184(51.67)(40.38-100)

C1 = 557.31

C2 = 855.64

C3 = 710.97

Avg = 707.97 J/C

Std Dev = 121.8 J/C

11. A good calorimeter prevents heat loss to its surroundings (the air around it, the table under it, etc.). Using the data you collected (both your graphs and calculated values), explain which material is the best calorimeter.

    Heat Capacity uses the measure J/C, meaning for every unit increase in temperature, how much energy an object absorbs. Taking our averages of 222.4 for the Styrofoam cups, 334.72 for the beaker, and 707.31 for the coffee mug, the heat capacities indicate how many joules of energy are lost or gained per degree Celsius. So, our coffee mug has the highest, so it wouldn't be a very ideal calorimeter if it quickly lost heat/energy for every degree of temperature lost. But the Styrofoam cups don't heat up quickly, and don't lose heat quickly, so I would say make the best calorimeter.

Determining Enthalpy of a Reaction

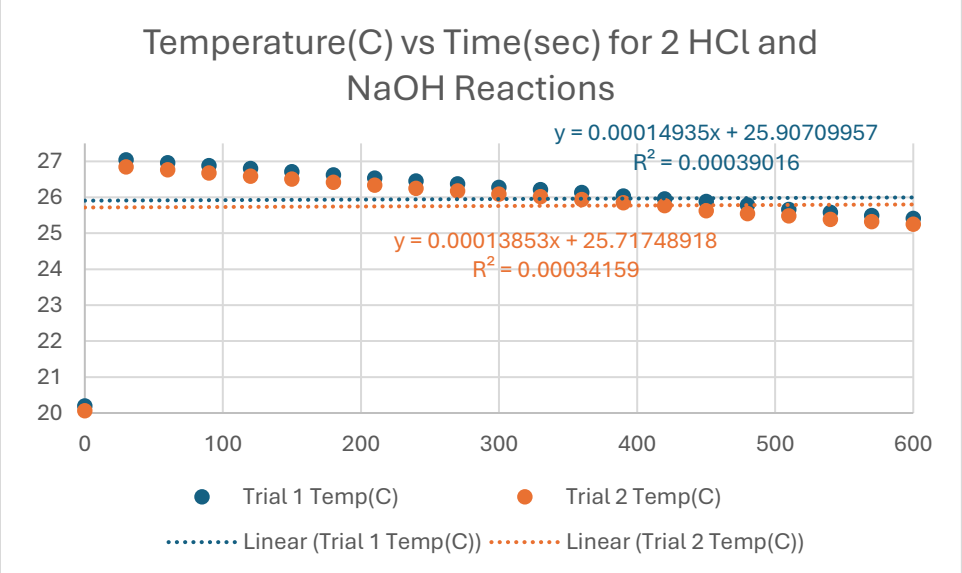
12. Make a table of your data from part D.

Table 4. Time and Temps for 2 Trials of HCl and NaOH reactions

Time (Seconds)	Trial 1 Temp(C)	Trial 2 Temp(C)
0	20.20	20.06
30	27.04	26.85
60	26.96	26.77
90	26.88	26.68
120	26.80	26.59
150	26.71	26.51
180	26.62	26.42
210	26.53	26.34
240	26.45	26.25
270	26.37	26.18

300	26.28	26.09
330	26.21	26.02
360	26.13	25.94
390	26.04	25.85
420	25.96	25.77
450	25.88	25.63
480	25.79	25.55
510	25.66	25.48
540	25.58	25.39
570	25.49	25.32
600	25.41	25.25

13. Create a plot of Temperature vs. Time from your part D data. This plot should include both trials, and the trials should be clearly marked. Include the value for final temperature and the mass of each solution for each trial in the caption of this plot.



Graph 4.. Cal. Temp vs Time for 2 HCl and NaOH Reactions(With Initial Temp). Final Temp1=25.41 C, Final Temp2=25.25 C, Final Mass1=113.94g, Final Mass2=113.66g

14. Show your entire calculation to determine the heat (**q**) released or absorbed by the reaction between NaOH and HCl for trial 1. Begin with a general formula and continue from there.

Qtotal = -(qsolution+qcalorimeter)

Qtotal = masssolution*C(water)*deltaT+ Cstyrofoam*deltaT

Qtotal = 113.94*4.184*(25.41-20.20) +222.4(25.41-20.20)

Qtotal = -3642.44

15. What is the average heat (**q**) of reaction from both trials? You do not need to show your work for this.

Trial 2 =

Qtotal = -(113.66*4.184*(25.25-20.06) + 222.4(25.25-20.06))

Qtotal = -3622.38

Qavg = -3632.41

16. Using your average heat (**q**) of reaction, determine the enthalpy of this reaction (**ΔH**) in kJ/mol. Show all your work for this question.

50ML of 1.1M HCl = .055mol

50ML of 1.9M NaOH = .05mol

NaOH is limiting reactant

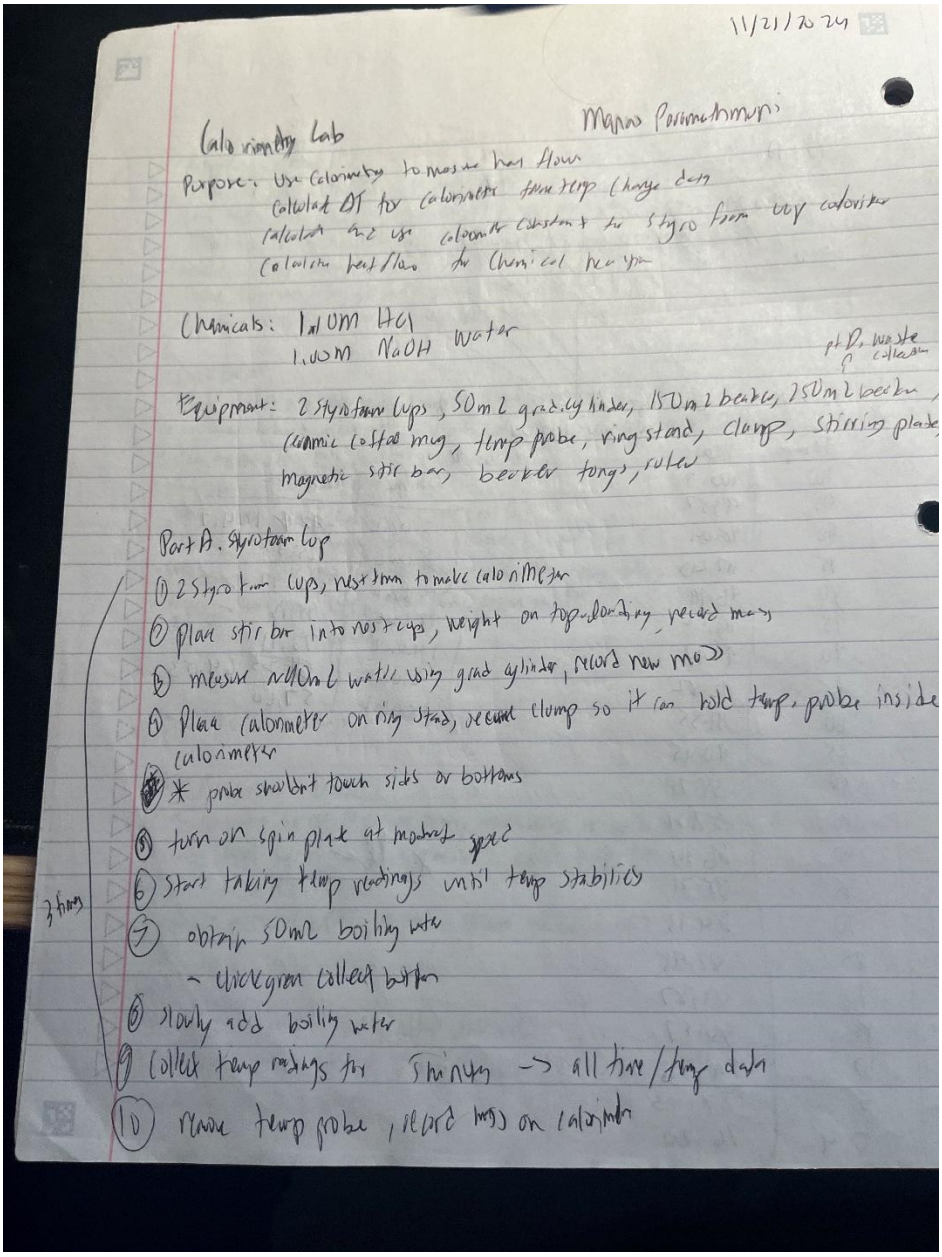
deltaH = q/n

deltaH = -3.63231 kJ /.05 mol

= -72.64 kJ/mol

Lab Notebook

Include ALL lab notebook pages and tag everything appropriately in Gradescope.



A, B, C - 10 data points
D - 20 data points

mixing = 0 seconds

Part B Beaker:
Obtain 150mL beaker - place stir bar into beaker and record mass
repeat part A 3 times

Part C, Coffee Mug
obtain coffee mug, measure mass with stir bar
- record weight, diameter, material, [illegible]

Part D:
Using part A tops, place stir bar, record mass
50ml cylinder to measure 50.0mL of 1.0M HCl, transfer to calorimeter
put on ring, [illegible] temp probe
- Stir, get constant 2 minute temp
- 50mL 1.00M NaOH
- collect button
- quickly add NaOH
- Record temp for 10 minutes
- remove calorimeter, record mass

Safety/Waste - Wear approved goggles
- use tongs when handling hot glassware
- no styrofoam directly on hot plate
- All waste in inorganic waste

$q_{cold} + q_{hot} + q_{cal} = 0$

$m_{water} \cdot c \cdot \Delta T + C \cdot \Delta T = 0$

[redacted] ~~TEAM MUSIC~~

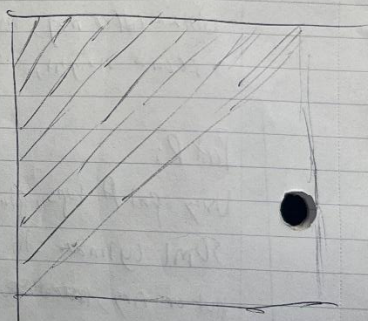
m_{Cu} = 9.6cm height, 7.3cm diameter 358.62 g + stirber

Part A: Calorimeter + Stir bar = 10.72 grams | 11.23 grams | 11.23 g

" + water$_1$ = 49.18 grams | 50.30 grams | 49.72 g

cold temp = 19.62°C final | 98.64 | 101.78 | 99.37

Time	Temp Trial$_1$	Temp Trial$_2$	Temp Trial$_3$
0	19.62	20.41	20.71
30sec	52.97	50.04	49.71
1min	52.29	49.55	48.95
1.5min	51.54	49.05	48.47
2min	50.98	48.55	47.97
2.5min	50.45	48.03	47.45
3min	49.88	47.49	47.01
3.5min	49.32	47.02	46.54
4.0min	48.79	46.56	46.10
4.5min	48.28	46.11	45.66
5min	47.73	45.66	45.25



part B:

Time	Trial, Temp	Trial 2 Temp	Trial 3 Temp
0	19.8	20.8	20.2
30	47.7	50.3	47.3
60	47.0	49.6	46.7
90	46.4	48.9	46.6
120	45.8	48.3	45.5
150	45.2	47.6	44.9
180	44.6	47.0	44.3
210	44.0	46.5	43.8
240	43.5	46.0	43.3
270	43.0	45.4	42.8
300	42.5	44.8	42.9
weight of cup	73.34	73.84	73.20
weight of cup with water	111.95	113.85	112.77
	160.67	163.29	161.16

Part C:

Time	T_1 Temp	T_2 Temp	T_3 Temp
0	20.84	25.46	25.65
30	45.70	43.55	47.55
60	43.65	42.46	45.60
90	42.62	41.66	44.61
120	41.85	41.00	43.78
150	41.18	40.42	43.13
180	40.52	39.90	42.58
210	39.91	39.39	42.01
240	39.36	38.90	41.45
270	38.85	38.44	40.89
300	38.34	38.00	40.38
~~Mass~~ 0 water	397.82 grams	398.89 grams	398.58 grams
mass styrbu	358.62	359.62	359.37

part D

weight with stir bar : 11.42 g , 11.35 g

weight with ~~water~~ HCl : 62.23 g , 61.13 g
11.394 11.400

Time	Trial, Temp	Trial 2 Temp
0	20.20	20.06
30	~~20~~ 27.04	26.85
60	26.96	26.77
90	26.88	26.68
120	26.80	26.59
150	26.71	26.51
180	~~26~~ 26.62	26.42
210	26.53	26.34
240	26.45	26.25
270	26.37	26.18
300	26.28	26.09
330	26.21	26.02
360	26.13	25.94
390	26.04	25.85
420	25.96	25.77
450	25.88	25.63
480	25.79	25.55
510	25.66	25.48
540	25.58	25.39
570	25.49	25.32
600	25.41	25.25