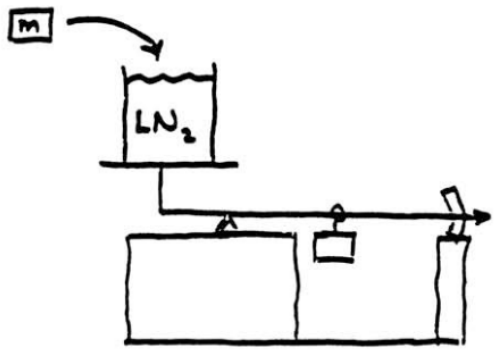
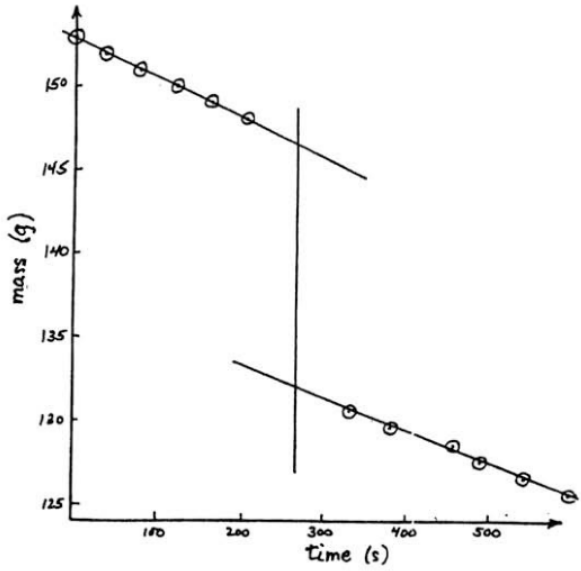
Experimental Problem 1 -- Solutions

Method #1



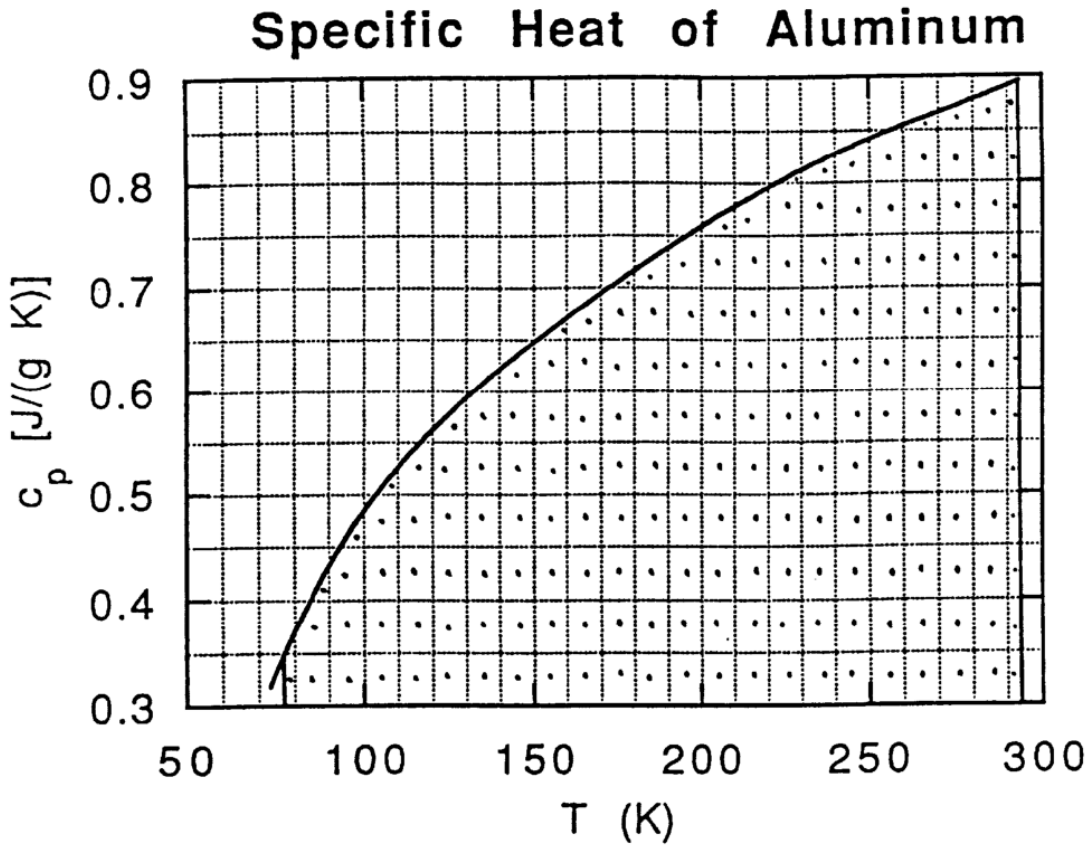
$$Q = mc\Delta T = m\int c\,\mathrm{d}T$$
$$Q = L\ \Delta M_{\mathrm{LN_2}}$$
$$m = 19.4 \pm 0.1\ \mathrm{g}$$

	total mass	clock time	time
	153 g	0:00.0	0
	152	0:36.8	36.8
	151	1:19.1	79.1
	150	2:00.7	120.7
	149	2:40.5	160.5
	148	3.23.1	203.1
Add Al mass			
	150 (130.6)	5:31.8	331.8
	149 (129.6)	6:21.6	381.6
	148 (128.6)	7:17.3	457.3
	147 (127.6)	8:08.6	488.6
	146 (126.6)	9:00.9	540.9
	145 (125.6)	9:54.6	594.6



$$\begin{aligned}\Delta M_{\mathrm{LN_2}} &= 146.5 - 132.0 \\ &= 14.5 \pm 0.3\ \mathrm{g}\end{aligned}$$

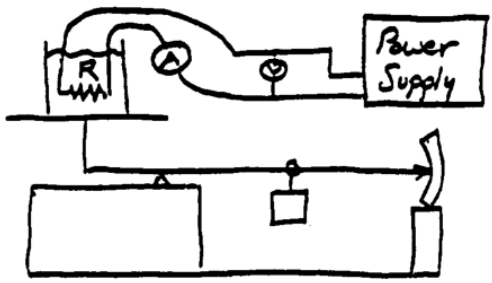
Method #1 (cont'd)



$$\int_{77}^{293} c\,\mathrm{d}T \approx (0.3)(293-77) + (173)(0.5)$$
$$\approx 64.8 + 86.5 = 151 \pm 2\ \mathrm{J/g}$$
$$Q = \int m\,c\,\mathrm{d}T = (19.4 \pm 0.1\ \mathrm{g})(151 \pm 2\ \mathrm{J/g})$$
$$= 2930 \pm 42\ \mathrm{J}.$$

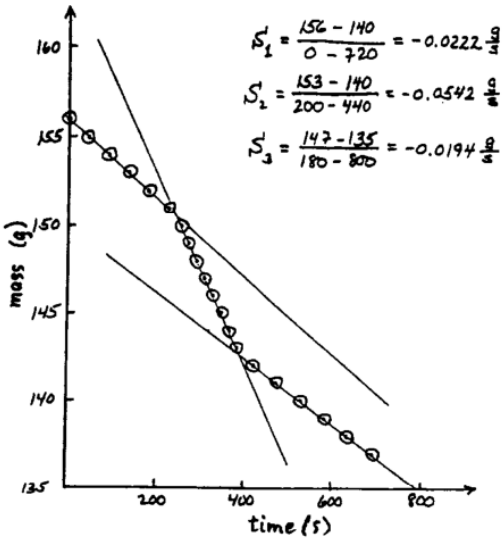
$$L = \frac{Q}{\Delta M_{\mathrm{LN2}}} = \frac{2930 \pm 42\ \mathrm{J}}{14.5 \pm 0.3\ \mathrm{g}} = 202 \pm 5\ \mathrm{J/g}$$

Method #2



$P = IV = V^2/R = I^2R$
$P = \Delta Q/\Delta t$
$Q = M_{\mathrm{LN}_2} L$
$R = 23.0\ \Omega$ (in LN_2)
$V = 12.7$ V
$I = 0.56$ A

	total mass	clock time	time
	156 g	0:00.0	0 s
	155	0:45.2	45.2
	154	1:31.4	91.4
$P = 0$	153	2:16.2	136.2
	152	2:60.0	180.0
	151	3:47.2	227.2
	150	4:13.6	253.6
	149	4:32.1	272.1
	148	4:50.1	290.1
$P \neq 0$	147	5:08.9	308.9
	146	5:27.2	327.2
	145	5:45.7	345.7
	144	6:04.1	364.1
	143	6:21.9	381.9
	142	7:02.3	422.3
	141	7:58.4	478.4
$P = 0$	140	8:51.2	531.2
	139	9:43.7	583.7
	138	10:34.6	634.6
	137	11:30.7	690.7



$$S_{P\neq 0} = -0.054 \pm 0.001 \text{ g/s}$$
$$\langle S_{P=0} \rangle = -0.020 \pm 0.001 \text{ g/s}$$

$$\text{Power} = P = \left| \frac{Q}{\Delta t} \right| = L \left| \frac{\Delta M_{\text{LN2}}}{\Delta t} \right|$$

$$\left.\begin{aligned} P &= IV & &= 7.11 \text{ W} \\ P &= I^2R & &= 7.21 \text{ W} \\ P &= V^2/R & &= 7.01 \text{ W} \end{aligned}\right\} \quad P = 7.1 \pm 0.1 \text{ W}$$

$$|\Delta M_{\text{LN}_2}/\Delta t| = 0.054 - 0.020 = 0.034 \pm 0.0014 \text{ J/s}$$

$$L = \frac{P}{\Delta M_{\text{LN2}}/\Delta t} = \frac{7.1 \pm 0.1}{0.034 \pm 0.0014} = 209 \pm 9 \text{ J/g}$$

Experimental Problem 1: Grading Scheme

Method No. 1 (5 points maximum)

1) 0.5 Uses $Q = mc\Delta T$ or $Q = m\int c\,\mathrm{d}T$
2) 0.5. Uses $Q = L\Delta M_{\mathrm{LN}_2}$
3) 0.5 Measures mass of aluminum correctly
4) 0.5 Measures ΔM_{LN_2} in some way
5) 0.5 Takes into account "thermal leakage" in some way and corrects for aluminum to container
6) 0.5 Takes into account "thermal leakage" not being constant in time
7) 0.5 Uses reasonable values for c and ΔT or does $\int c\,\mathrm{d}T$ integral in a reasonable wa
8) 0.5 No mistakes made in computing L
9) 0.5 Error estimate is reasonable for methods used
10) 0.5 Value for L is within bounds set by grading team using good procedures

Method No. 2 (5 points maximum)

1) 0.5 Uses $P = \Delta Q/\Delta t$
2) 0.5 Uses $P = IV = I^2R = V^2/R$
3) 0.5 Uses $Q = LM_{\mathrm{LN}_2}$
4) 0.5 Measures two parameters (to get P) correctly
5) 0.5 Measures M_{LN_2} in some way
6) 0.5 Takes into account "thermal leakage" in some way
7) 0.5 Takes into account "thermal leakage" not being constant in time
8) 0.5 No mistakes made in computing L
9) 0.5 Error estimate is reasonable for methods used
10) 0.5 Value for L is within bounds set by grading team using good procedures