4. Experimental Objectives

1) Learn to measure temperature using PT100 platinum resistance;
2) Under forced convective cooling, measure specific heat capacity of iron and aluminum samples at 100 °C;
3) Under natural cooling, measure specific heat capacity of iron and aluminum samples at 100 °C.

5. Precautions

1) It is recommended to turn on the heater and preheat for about 20 minutes before doing experiment;
2) When the heater is working, do not block the heat dissipation holes of the enclosure;
3) Before replacing the sample, please turn on the fan to cool down the current sample, be sure to wait until the temperature drops below 50 ℃ and then replace it manually to avoid burns;

6. Experimental Procedures

1) Connect the heater and fan to the main electric unit through cables. The two leads at the end of the slide bar are the two ends of the PT100 platinum resistance, and connect them to the electric unit through connection wires.
2) Turn on the power of main electric unit, pull the slide bar to the end, then turn on the heater power and preheat for about 20 minutes.
3) Weigh and record the masses of the three metal samples of copper, iron, and aluminum with a physical balance or an electronic balance (the three samples can be distinguished according to the characteristic $M_{Cu} > M_{Fe} > M_{Al}$ of the same volume).
4) Measure the specific heat capacity of iron and aluminum samples at 100 °C under forced convection cooling
    a) Turn on the power of the fan; open the upper cover of the sample chamber; place the copper sample on the stainless steel cylinder encapsulated with PT100 platinum resistance; and manually screw on the thread at the bottom of the sample (note that it is not necessary to screw it tightly) ; put back the upper cover.
    b) Push the slide bar to the end to let the sample enter the heater. Observe the resistance of the PT100 platinum resistance. When the temperature of the platinum resistance exceeds a certain value (such as 120 °C or 146.07 Ω), pull out the slide bar immediately. At this time, fan is just performing forced convection cooling to the sample. Due to the delay caused by heat conduction, the temperature measured by the platinum resistance will rise for a period of time before it starts to fall.
    c) When the temperature drops to 105 ℃ (i.e. 140.40 Ω), press the stopwatch to start timing (because the value of the ohm meter on the panel is not continuous, so you can immediately press the stopwatch when reading drops to 140.40 Ω or less). When it downs to 95 ℃ (i.e. 136.61 Ω), press the stopwatch again to stop timing. Record the time Δt , and repeat the measurement 5 times.

d) When the temperature of the sample drops below 50 °C (i.e. 119.40 Ω), replace the sample, measure the Δt for iron and aluminum samples, and calculate the specific heat capacity of the iron and aluminum samples using equation (8).

5) Measure the specific heat capacity of iron and aluminum samples at 100 °C with naturally cooling

Turn off the power of the fan, measure and calculate the specific heat capacity of the three samples of copper, iron and aluminum in the same way as described in the previous experimental process, and compare the results of the two cooling methods. (the fan can be used for cooling when replacing the sample).

6) Turn off the heater after the experiment is completed, the fan can be used to cool the sample, and then remove the sample, turn off the fan and the electric unit.

7. An example of data recording and processing

Note: Following data are for reference only, not the criteria for apparatus performance.

Sample mass: Copper $M_{Cu}=18.34g$, Iron $M_{Fe}=18.07g$, Aluminum $M_{Al}=6.50g$

1. Under forced convective cooling, measure the specific heat capacities of samples iron and aluminum at 100 °C

Table 1 The spent cooling time from 105 °C to 95 °C for 3 metal samples

	$\Delta t / s$					Average
	1	2	3	4	5	$\overline{\Delta t} / s$
Copper	16.97	17.22	17.25	17.16	17.25	17.17
Iron	20.40	20.54	20.38	20.22	21.13	20.53
Aluminum	12.84	13.38	13.56	13.47	13.94	13.44

Use Copper as the standard sample: $C_1 = C_{Cu} = 0.39J/(g\cdot℃)$

Calculated specific heat capacities are follows:

Iron sample $C_2 = C_1 \frac{M_1(\Delta t)_2}{M_2(\Delta t)_1} = 0.39 \times \frac{18.34 \times 20.53}{18.07 \times 17.17} = 0.47J/(g\cdot℃)$

Aluminum sample $C_3 = C_1 \frac{M_1(\Delta t)_3}{M_3(\Delta t)_1} = 0.39 \times \frac{18.34 \times 13.44}{6.50 \times 17.17} = 0.86J/(g\cdot℃)$

2. Under natural cooling, measure the specific heat capacities of samples iron and aluminum at 100 °C

Table 2 The spent cooling time from 105 °C to 95 °C for 3 metal samples

	$\Delta t / s$					Average
	1	2	3	4	5	$\overline{\Delta t} / s$
Copper	29.72	30.81	31.53	32.16	32.84	31.41
Iron	38.34	39.44	39.82	40.41	41.12	39.83
Aluminum	22.25	23.19	23.75	23.94	24.10	23.45

Use Copper as the standard sample : $C_1 = C_{Cu} = 0.39J/(g\cdot℃)$

Calculated specific heat capacities are follows:

Iron sample : $C_2 = C_1 \frac{M_1(\Delta t)_2}{M_2(\Delta t)_1} = 0.39 \times \frac{18.34 \times 39.83}{31.41 \times 18.07} = 0.50 J/(g \cdot ℃)$

Aluminum sample: $C_3 = C_1 \frac{M_1(\Delta t)_3}{M_3(\Delta t)_1} = 0.39 \times \frac{18.34 \times 23.45}{6.50 \times 31.41} = 0.81 J/(g \cdot ℃)$

Conclusion: method of forced convective cooling can achieve relatively better measurement results as they are closer to recognized values for iron and aluminum samples.

8. Appendix: Temperature-Resistance Table of Pt100 (-40 ℃—299 ℃)

T (℃)	0	1	2	3	4	5	6	7	8	9
	Resistance (Ω)									
-40	84.27	83.87	83.48	83.08	82.69	82.29	81.89	81.50	81.10	80.70
-30	88.22	87.83	87.43	87.04	86.64	86.25	85.85	85.46	85.06	84.67
-20	92.16	91.77	91.37	90.98	90.59	90.19	89.80	89.40	89.01	88.62
-10	96.09	95.69	95.30	94.91	94.52	94.12	93.73	93.34	92.95	92.55
0	100.00	99.61	99.22	98.83	98.44	98.04	97.65	97.26	96.87	96.48
0	100.00	100.39	100.78	101.17	101.56	101.95	102.34	102.73	103.12	103.51
10	103.90	104.29	104.68	105.07	105.46	105.85	106.24	106.63	107.02	107.40
20	107.79	108.18	108.57	108.96	109.35	109.73	110.12	110.51	110.90	111.29
30	111.67	112.06	112.45	112.83	113.22	113.61	114.00	114.38	114.77	115.15
40	115.54	115.93	116.31	116.70	117.08	117.47	117.86	118.24	118.63	119.01
50	119.40	119.78	120.17	120.55	120.94	121.32	121.71	122.09	122.47	122.86
60	123.24	123.63	124.01	124.39	124.78	125.16	125.54	125.93	126.31	126.69
70	127.08	127.46	127.84	128.22	128.61	128.99	129.37	129.75	130.13	130.52
80	130.90	131.28	131.66	132.04	132.42	132.80	133.18	133.57	133.95	134.33
90	134.71	135.09	135.47	135.85	136.23	136.61	136.99	137.37	137.75	138.13
100	138.51	138.88	139.26	139.64	140.02	140.40	140.78	141.16	141.54	141.91
110	142.29	142.67	143.05	143.43	143.80	144.18	144.56	144.94	145.31	145.69
120	146.07	146.44	146.82	147.20	147.57	147.95	148.33	148.70	149.08	149.46
130	149.83	150.21	150.58	150.96	151.33	151.71	152.08	152.46	152.83	153.21
140	153.58	153.96	154.33	154.71	155.08	155.46	155.83	156.20	156.58	156.95
150	157.33	157.70	158.07	158.45	158.82	159.19	159.56	159.94	160.31	160.68
160	161.05	161.43	161.80	162.17	162.54	162.91	163.29	163.66	164.03	164.40
170	164.77	165.14	165.51	165.89	166.26	166.63	167.00	167.37	167.74	168.11
180	168.48	168.85	169.22	169.59	169.96	170.33	170.70	171.07	171.43	171.80
190	172.17	172.54	172.91	173.28	173.65	174.02	174.38	174.75	175.12	175.49
200	175.86	176.22	176.59	176.96	177.33	177.69	178.06	178.43	178.79	179.16
210	179.53	179.89	180.26	180.63	180.99	181.36	181.72	182.09	182.46	182.82
220	183.19	183.55	183.92	184.28	184.65	185.01	185.38	185.74	186.11	186.47
230	186.84	187.20	187.56	187.93	188.29	188.66	189.02	189.38	189.75	190.11
240	190.47	190.84	191.20	191.56	191.92	192.29	192.65	193.01	193.37	193.74
250	194.10	194.46	194.82	195.18	195.55	195.91	196.27	196.63	196.99	197.35
260	197.71	198.07	198.43	198.79	199.15	199.51	199.87	200.23	200.59	200.95
270	201.31	201.67	202.03	202.39	202.75	203.11	203.47	203.83	204.19	204.55
280	204.90	205.26	205.62	205.98	206.34	206.70	207.05	207.41	207.77	208.13
290	208.48	208.84	209.20	209.56	209.91	210.27	210.63	210.98	211.34	211.70