Stefan Boltzmann's Radiation Law

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1. Aim:

- To verify Stefan Boltzmann's law for a blackbody, and determining the Stefan Boltzmann constant.
- To graph a straight line with slope equal approximately "4".

2. Principle:

In this experiment, an electric oven with a blackbody accessory is used as the "blackbody". We measured the thermal radiation using a Moll's thermocouple (thermopile) which is connected to a microvoltmeter box, as a function of temperature. After the temperature of the electric oven reaches 100°C, we recorded its temperature increase every 25°C until a level between 400°C and 500°C. We plotted two graphs to determine the Stefan Boltzmann constant, and to get a straight line with slope "4".

3. Data:

Initial temperature of the blackbody (the electric oven) : $T_o = 21°\text{C} = 294\ K$

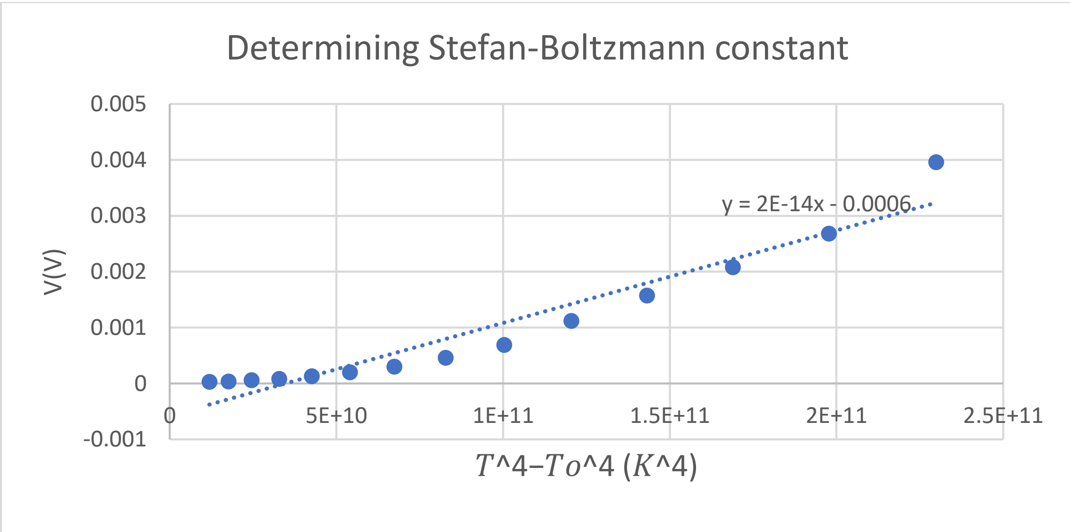
Area of the blackbody: $A = 3.1 \times 10^{-7} m^2$

Theoretical value of Stefan Boltzmann constant $\sigma = 5.6696 \times 10^{-8} W m^{-2} K^{-4}$

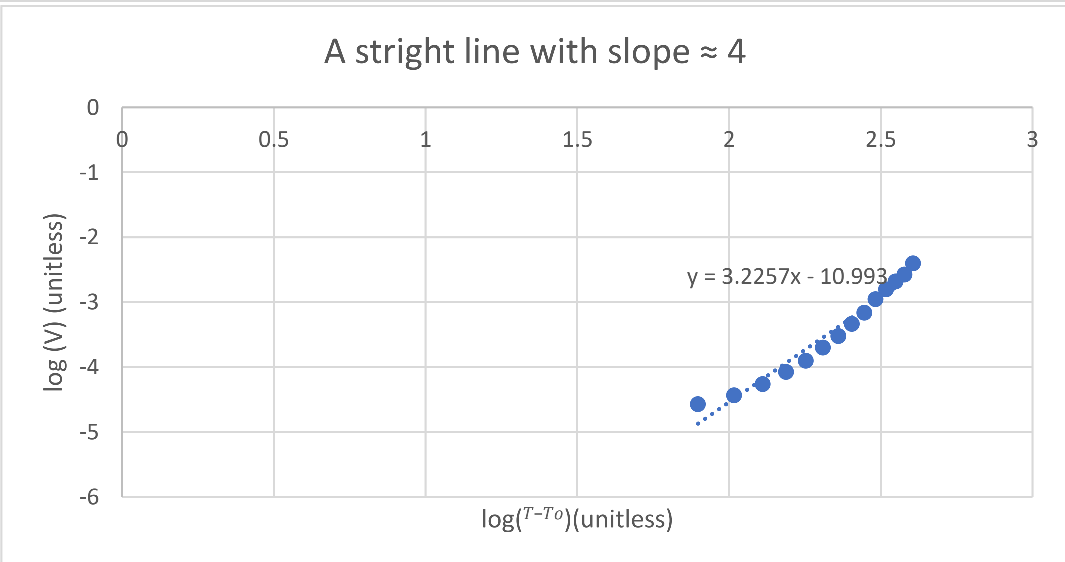
Theoretical value of the slope in graph2 = 4

4. Graphs:

Graph 1 :



Graph 2 :



5. Calculations:

T_o(°C)	T_o(K)	$T_o^4\ (K^4)$
21	294	7471182096

T(°C)	T(K)	$T^4(K^4)$	$T^4 - T_o^4(K^4)$	T-T_o (K)	Log (T-T_o)	V(mV)	V(V)	Log (V)
100	373	19356878641	11885696545	79	1.897627091	0.027	0.000027	-4.56864
125	398	25091827216	17620645120	104	2.017033339	0.037	0.000037	-4.4318
150	423	32015587041	24544404945	129	2.11058971	0.055	0.000055	-4.25964
175	448	40282095616	32810913520	154	2.187520721	0.084	0.000084	-4.07572
200	473	50054665441	42583483345	179	2.252853031	0.126	0.000126	-3.89963
225	498	61505984016	54034801920	204	2.309630167	0.2	0.0002	-3.69897
250	523	74818113841	67346931745	229	2.359835482	0.302	0.000302	-3.51999
275	548	90182492416	82711310320	254	2.404833717	0.461	0.000461	-3.3363
300	573	1.078E+11	1.00329E+11	279	2.445604203	0.689	0.000689	-3.16178
325	598	1.27881E+11	1.20409E+11	304	2.482873584	1.117	0.001117	-2.95195
350	623	1.50644E+11	1.43173E+11	329	2.517195898	1.573	0.001573	-2.80327
375	648	1.76319E+11	1.68848E+11	354	2.549003262	2.08	0.00208	-2.68194
400	673	2.05145E+11	1.97673E+11	379	2.57863921	2.68	0.00268	-2.57187
425	698	2.37368E+11	2.29897E+11	404	2.606381365	3.96	0.00396	-2.4023

Part1:

Determining the experimental value of Stefan Boltzmann constant:

from the graph1 The slope =$2x10^{-14}$

$$\sigma = \frac{P}{AT^4} \approx \frac{V}{AT^4} = \frac{slope}{A} = \frac{2\times10^{-14}\frac{V}{K^4}}{3.1\times10^{-7}m^2} = 6.4516\times10^{-8}\ VK^{-4}m^{-2} \approx 6.4516\times10^{-8}\ WK^{-4}m^{-2}$$

Percentage of error: E% = 13.8 %

Part2:

Getting a straight line with slope approximately "4":

$$P = \sigma AT^4$$
$$\log(P) = log\sigma A + 4\log(T)$$
$$\log(V) = log(\sigma A) + 4\log(T - T_o)$$
$$y = b + mx$$

By ignoring the b terms we found it to be m=y/x

So from the graph2 The slope of the straight line: Slope = 3.2257

Percentage of error: E% = 19 %

6. Conclusion:

Our data showed that in part one from graph1 we found the experimental value of the Stefan Boltzmann constant and we saw that it’s close to the theoretical value with 13.8% percent using a thermopile which converts thermal energy into electrical energy. In the second part from our data the graph2 shows the slope of the straight line to be 3.2257 and when we take the error that shows 19% .

7. Evaluation:

The experiment was good at helping us achieving our aims, as we determine the Stefan Boltzmann constant, and have got a straight line with slope ≈ 4. We can make the experiment go more smoothly, and get reliable results by mounting the temperature sensor in fixed place, making sure to remove the glass window of the thermopile and recording the results with high accuracy. We see that we didn't have such big anomalies to mention in this experiment.