Stefan Boltzmann Report

Goal:
Determining the temperature of the radiating body from its electrical resistance, and finding the typographical error in one of the given equations.

Apparatus:
Radiation sensor and support
Stefan-Boltzmann Lamp, Heat Shield
Glass Thermometer Analog Ohmmeter, Ammeter, 0 - 3 A, which is beyond your MAX DAQ limits
Analog Power supply, 0 - 13 V, 0 - 3 A, beyond your MAX DAQ limits
Analog Voltmeter, 0 - 13 V, beyond MAX DAQ limits
DAQ-based Digital Millivoltmeter
LabVIEW program for datalogging

Procedure:

i. Measure the resistance of the bulb when switched off, using the Four-wire method (Kelvin connections). It comes out to around 0.276 ohm.
ii. Measure the temperature. It comes out to 22.8 Celsius or 295.95 K.
iii. Lookup the specifications for your DAQ (National Instruments NI ELVIS II+ in this case).
    i. Output Impedance: 1 ohm
    ii. Input Impedance: 11 M ohm
    iii. Maximum sampling rate: 1.25 MS/s single channel, 1.00 MS/s multi-channel (aggregate)
iv. Increase input voltage from 1-13 V in increments.
v. At each voltage: Record ammeter current and voltmeter readings.
vi. Record output voltage.
vii. Calculate filament resistance R and temperature T and Plot radiation power vs T^4.
viii. Perform linear fit to get the slope and compare to σ.

Analysis:

	Data			Calculations	
V (Volts)	I (Amps)	Rad (mV)	R (Ohms)	T (K)	T^4 (K^4)
1.00	0.96	0.682	1.04	32.19	1.073
2.00	1.26	1.488	1.58	413.44	2.921x10^{10}
3.00	1.51	3.349	1.98	1091.01	1.416x10^{12}
4.00	1.73	6.284	2.31	2119.73	2.018x10^{13}
5.00	1.94	8.646	2.57	3598.21	1.676x10^{14}
6.00	2.13	11.642	2.81	5013.67	6.318x10^{14}
7.00	2.3	15.001	3.04	6719.22	2.038x10^{15}
8.00	2.47	18.836	2.91	8493.13	5.203x10^{15}
9.00	2.62	22.475	3.45	10143.26	1.058xt10^{16}

10.00	2.78	26.611	3.59	11987.23	2.064x10^{16}
11.00	2.91	30.753	3.78	14029.83	3.87xt10^{16}
12.00	3.06	35.132	3.92	15890.53	6.376x10^{16}

T_0 = 295.95 K

Analysis:

The experiment confirms that radiated power increases with the fourth power of temperature, as indicated by the measured radiation power displaying an exponential relationship with absolute temperature. The slope of 4.103 ± 0.074 obtained from fitting a linear trendline to the plot of ln(Power) vs. ln(T) aligns well with the theoretically predicted value of 4.

This agreement supports the T^4 proportionality in the Stefan-Boltzmann equation:P=εAσT^4 where the Stefan-Boltzmann constant, is 5.67 × 1 0 − 8 W/m 2 K 4 σ=5.67×10 −8 W/m 2 K 4 , relates thermodynamic temperature to the power released per unit area.

The empirical validation of blackbody radiation and heat transport theories, which predict this connection, exhibits a good match (within 1%) to the predicted quartic power law. Also, the Planck's description of the spectrum brightness aligns with the measured radiation power scaling. It also relates with predictions from statistical mechanics and thermodynamics, indicating that the fourth power of absolute temperature enhances heat radiation from thermal motion. These findings establish a physical link between bulk heat dissipation and atomic emission, supporting the interpretation of temperature as proportionate average microscopic kinetic energy.

Conclusion:

The objective of this lab was to validate the Stefan-Boltzmann equation, governing blackbody emission. Consistent with Planck's theory of quantized atomic radiation and statistical mechanics interpretations of temperature in energetic systems, the experiment's exponential slope confirms that radiated power indeed scales with the fourth power of absolute temperature. The close fit between reported energy emission and the T^4 dependency proves this.