Stefan-Boltzman Constant

Aditya Raj

Session 2024-25

1 Aim

To verify Stefan-Boltzman constant.

2 Apparatus Required

- Ammeter
- Voltmeter
- Rheostat
- Stefan-Boltzman constant apparatus

3 Theory

There is no more law in environmentally relevant physics than the realtionship between the power radiated by dense hot body and temperature

$$P = eA\sigma T^4 \tag{1}$$

where T is the absolute temperature, A is surface area of the radiation, e is emissivity of the radiation, a function of emitted wavelength and σ is Stefan-Boltzman constant. For a perfect blackbody $e = 1$. The Stefan-Boltzman constant e is equal to $5.67 \times 10^{-8} \frac{W}{m^2 K^4}$.
To investigate this T^4 dependence we need a source of radiation and a detector of radiation. Our souce is a light bulb with a tungsten filament. There is nothing special about this light bulb, infact it is common automotive heading bulb, but it is set up to allow convenient measurement of the current passing through it and the voltage across it. We can vary the filament temperature

by adjusting the voltage and we an determine the temperature by calculating the resistance.
$P = VI$ at each voltage setting. The resistance of filament is highly temperature dependent and serves as a thermometer.
Our detector is a device known as thermopile. It has a very wide range, detecting with equal efficiency radiation from 0.5 microns to 25 microns in wavelength. This covers the visible range, 0.5 microns to 0.8 microns in wavelength and large stretch of infrared region. The temperature at which filament can operate, $T < 3000K$, most of the radiation is in infrared region.

4 Observation

Table 1: Determination of temperature for Tungsten ($R_{300} = 0.6\,\Omega$)

Sl. No	$\frac{R_T}{R_{300}}$	**T(K)**
1	1	300
2	4	920
3	6	1300
4	8	1645
5	10	1990

Table 2: Data taken from current and voltage

Volt (V)	**I (mA)**	**R (Ω)**	**P (W)**	$\frac{R_T}{R_300}$	**T(K)**	**log (T)**	**log K**
1	17.5	57.14	0.0170	95.23	18253.7	4.26	-1.75
2.5	25	100	0.0625	166.6	31814	4.50	-1.2
3.5	30	116.6	0.105	194.3	37077	4.56	-0.9
5	37.5	133.3	0.187	222.1	42378	4.62	-0.7
6.5	45	144.4	0.292	240.6	45874	4.66	-0.53
8.5	52.5	161.9	0.446	269.8	51422	4.711	-0.3
10.7	62.5	163.2	0.637	272	51840	4.714	-0.19
11.5	67.5	170.3	0.776	283.8	54082	4.73	-0.13

5 Final Result

$$\begin{aligned}
\text{Slope of } \log P \text{ vs } \log T &= \frac{y_2 - y_1}{x_2 - x_1} \\
&= \frac{30 \times 0.02}{15 \times 0.01} \\
&= 4
\end{aligned}$$

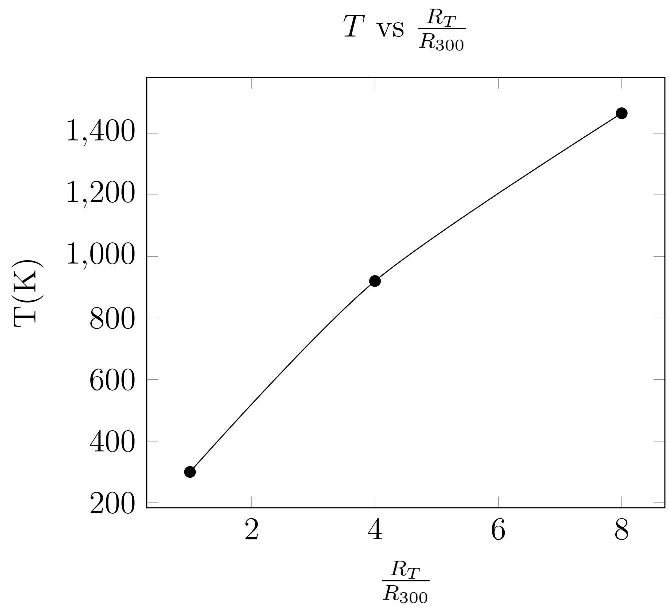
6 Error Calculation

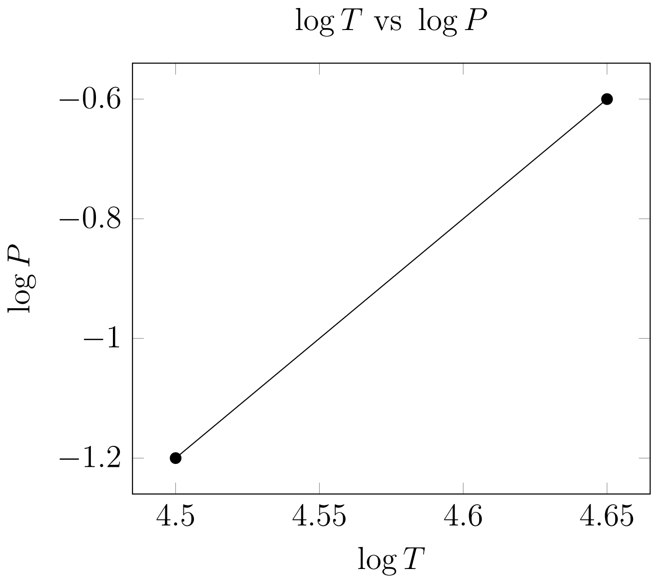
$$\begin{aligned}\frac{\partial n}{n} &= \frac{\partial \log P}{\log P} + \frac{\partial \log T}{\log T} \\ &= \frac{0.01}{15} + \frac{0.02}{30} \\ &= 0.0013\end{aligned}$$

$$\begin{aligned}\% \text{ error} &= \frac{\partial n}{n} \times 100 \\ &= 0.13\%\end{aligned}$$

7 Graphs

Needs to be drawn by hand. Given here for reference.





$\log T$ vs $\log P$
-0.6
-0.8
-1
-1.2
$\log P$
4.5
4.55
4.6
4.65
$\log T$