EXPERIMENT NO. 7

VERIFICATION OF STEFAN'S LAW BY ELECTRICAL METHOD

OBJECT:

To verify Stefan's law by electrical method.

APPARATUS:

6V battery, D.C. Voltmeter (0-10V), D.C. Miliammeter, Electric bulb having tungsten filament.

FORMULA USED:

The power emitted from a unit surface area per second by a body other than black body is given as

$$P = CT^{\alpha},$$

Where P is the power emitted by a body at temperature T and C are some constants depends on the material of the body.

THEORY:

Let E be the total energy radiated per second from a unit surface area of a black body at temperature T surrounded by another body at temperature T_0, and then by Stefan's law we have

$$E = \sigma\left(T^4 - T_0^{\,4}\right), \qquad (1)$$

Where σ is Stefan's constant. For other bodies other than black body, a similar relation for power emitted by a body at temperature T surrounded by another body at temperature T_0 is given by

$$P = C\left(T^{\alpha} - T_0^{\,\alpha}\right) \qquad (2)$$

Where C is a constant which depends on the material and area of the body and α is a power very close to 4. Equation (2) can be written as

$$P = CT^{\alpha}\left(1 - \frac{T_0^{\,\alpha}}{T^{\alpha}}\right) \qquad (3)$$

If $T >> T_0$ then

$$P = CT^{\alpha} \qquad (4)$$

Now taking log of equation (4) from both the sides, we get

$$\log P = \alpha \log T + \log C \tag{5}$$

Equation (5) represents a straight line with slope α. The slope of the line can be found from a curve between $\log P$ versus $\log T$. If α is approximately equal to 4, then Stefan's law is verified.

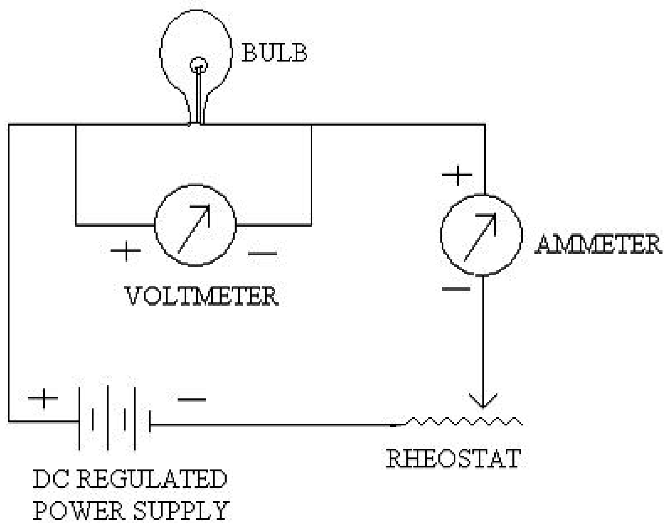

Figure 1. Circuit diagram for verification of Stefan's Law by electrical method

PROCEDURE:

(A) For table (a)

(1) Make the connection as shown in figure (1).

(2) Set a voltage in voltmeter to just glow the filament of bulb and note down the corresponding value of current.

(3) Take at least 3 reading in just glow position in increasing order of current.

(B) For table (b)

(1) Now increase the voltage enough to get brightness in bulb's filament.

(2) Increase the voltage in small step and cover the whole range of voltage and note down the corresponding value of current.

OBSERVATIONS:

Table (a) Determination of R_g (Temperature of filament $= 800\ K$)

S.No.	Current Increasing		
	Voltage V **(In Volts)**	**Current** I **(In Amp)**	$R_g = \frac{V}{I}\ Ohm$
1.			
2.			
3.			

Table (b) Determination of power dissipated P , at different temperature T

S.No.	**Voltage** V **(In Volts)**	**Current** I **(In Amp)**	**Power** $P = VI$	$\log P$	**Resistance** $R_t = \frac{V}{I}\ (Ohm)$	$\frac{R_t}{R_0}$	**Temperature** $T\left({}^0 K\right)$ **from graph**	$\log T$
1. 2. 3. . . 20.								

CALCULATIONS:

(1) Determine the mean value of filament resistance R_g of bulb at just glow condition. Further calculate $R_0 = \frac{R_g}{3.9}$ Ohm.

(2) Plot a standard curve between temperature $T\left({}^{0}K\right)$ versus $\dfrac{R_t}{R_0}$ using data from table (c).

Find experimental value of temperature T from the projected values of $\dfrac{R_t}{R_0}$ calculating form table (b).

(3) Plot a curve between $\log P$ versus $\log T$ which comes out to be a straight line. Find the slope α of the line that comes out around 4 to verify Stefan's law of radiation.

RESULT:

(1)The graph of $\log P$ versus $\log T$ comes out to be a straight line having slope α .

Hence $P \;=\; CT^{\alpha}$ law is verified. Further the slope of the line α = 4 and therefore the law is verified as a fourth power law.

(2) **Standard result**

The value of slope α = 4.0.

(3) **Experimental result**

The value of slope α obtained from experimental data = ……….

% ERROR:

$$\%\,Error \;=\left(\frac{Standard\ Value - Experimental\ Value}{Standard\ Value}\times 100\right) = \text{………}$$

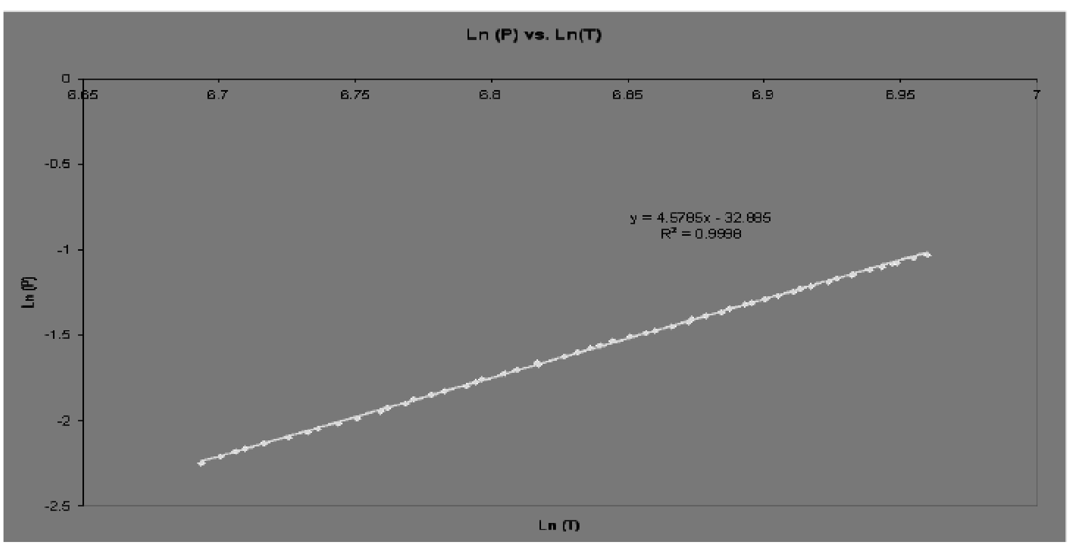

Figure 2. Typical graph between log P versus log T to find the slope

PRECAUTIONS:

(1) There should be least value of voltage to obtain the just glow condition in increasing order of current.

(2) To obtain the condition of brightness in filament of bulb the voltage should be increased in small step.

(3) The whole range of voltage should be covered to get the desired result.

(4) Slope of the line should be calculated accurately.

(5) Increase the current in steps.

(6) Reading should be noted after the system is stable.

Table (c) Table for plotting Temperature T versus $\frac{R_t}{R_0}$

Temperature $T\left({}^0C\right)$	$\frac{R_t}{R_O}$	**Temperature** $T\left({}^0C\right)$	$\frac{R_t}{R_O}$
0	1.00	1100	7.60
100	1.53	1200	8.26
200	2.07	1300	8.90
300	2.13	1400	9.70
400	3.22	1500	10.43
500	3.80	1600	11.17
600	4.40	1700	11.42
700	5.00	1800	12.67
800	5.64	1900	13.50
900	6.37	2000	14.30
1000	6.94	-----	------

VIVA –VOCE

(1) What is Stefan's law for black body radiation?
(2) What is a black body?
(3) What is non-black body?
(4) Is Ohm's law valid for your experiment?
(5) What are the applications of Stefan's law?
(6) What is radiating body in your experiment?
(7) What do you mean by radiation?
(8) What is absorptive power?
(9) What is emissive power?
(10) What is Stefan's constant?