INSTRUCTION MANUAL

STEFAN'S CONSTANT KIT

MITTAL ENTERPRISES
2151/T-7C, New Patel Nagar, New Delhi-110008
Ph. : 25702784 (Off.) 25120261 (Res.); Fax : 25120261
Mobile: 9810681132
E-mail : mittalenterprises@bol.net.in

STEFAN'S CONSTANT KIT

INTRODUCTION

According to Stefan-Boltzmann's law the heat energy E_1 radiated per unit area per second by a body at T° Kelvin surrounded by another body at lower temperature T_0° Kelvin is directly proportional to the difference in fourth power of the absolute temperature i.e.

$$E_1 \propto (T^4 - T_o^4)$$

or

$$E_1 = \sigma \cdot (T^4 - T_o^4)$$

where σ is called Stefan's Constant. Its standard value is 5.67×10^{-8} W m^{-2} K^{-4}. If the area of surface is A, then the head energy radiated from the surface becomes

$$E_1 = \sigma \cdot A \cdot (T^4 - T_o^4) \qquad \ldots(1)$$

THEORY

In this kit, the electric energy is used to heat up the two copper circular discs to a particular steady temperature T° K. The steady temperature is measured by thermometers placed in contact with the copper discs. As the steady temperature of the discs is larger than surrounding temperature T_o °K of the atmosphere, the disc will radiate heat energy which can be calculated by Stefans Boltzmann's Law or eqn. (1).

As the temperature of the discs reaches steady state, heat energy, E_1, radiated by discs per second will be equal to the electrical energy, E_2, consumed by heating element per second and is given by

$$E_2 = V \cdot I \qquad \ldots(2)$$

where V = Potential difference across the heating element and

I = Current flowing in the heating element

From equations (1) & (2)

$$V \cdot I = \sigma \cdot A \cdot (T^4 - T_o^4)$$

or $$\sigma = \frac{V \cdot I}{A \cdot (T^4 - T_o^4)} \qquad \ldots(3)$$

V and I can be measured with the help of Voltmeter and Ammeter installed in the kit. The steady temperature (T °K) of copper discs can be read from the thermometers and the area A of the disc can be calculated by measuring the radius of the disc.

By substituting the values of V, I, A, T and T_o in equation (3) one can calculate the Stefan's constant.

The features of the kit are:

i) There is practically no loss of heat energy from heating element by conduction, convection or radiation. Therefore, entire heat energy of the heating element is transferred to discs.

ii) As the efficiency of the heating element is nearly equal to one, almost entire electrical energy supplied to the heater will be converted into heat energy.

PROCEDURE

i) Note down the surrounding room temperature (T °K) with the help of the thermometers.

ii) Put ON the switch on the kit.

iii) Place the discs horizontally on the table.

iv) Connect the heating element of discs to the Kit terminals marked "H".

v) Adjust with the help of potentiometer, the potential difference (V) and current (I) for heating element for proper reading in the meters.

vi) Place the thermometers vertically in the holes provided in the discs.

vii) Observe the readings of the thermometers till the readings become steady. Take the average of the readings.

viii) The several sets of observations are taken by varying the potential difference (V) & current (I) with the help of potentiometer.

ix) The area of the plate can be calculated by measuring the radius of the disc.

SAMPLE OBSERVATIONS

The area of the copper plates = 306.8056 sq. cm.

Least Count of Thermometer = 1 °C.

S.No.	Voltage	Current	Room Temp. T °K	Mean Temp. of Thermometers T °K
1	20	0.25	300	328
2	30	0.35	300	395
3	40	0.47	300	376
4	50	0.58	300	404

SAMPLE CALCULATIONS

$$\sigma = \frac{V \cdot I}{A \cdot (T^4 - T_o^4)} \text{ W cm}^{-2} \text{ K}^{-4}$$

$$\sigma = \frac{V \cdot I \times 10^7}{A \cdot (T^4 - T_o^4)} \text{ ergs cm}^{-2} \text{ sec}^{-1} \text{ K}^{-4}$$

Thus substituting values from table :

1)
$$\sigma = \frac{20 \times 0.25 \times 10^7}{306.8056 \cdot (328^4 - 300^4)}$$

$$= \frac{20 \times 0.25 \times 10^7}{306.8056 \times 3.482 \times 10^9}$$

$$= 4.679 \times 10^{-5} \text{ erg cm}^{-2} \text{ sec}^{-1} \text{ K}^{-4}$$

2)
$$\sigma = \frac{30 \times 0.35 \times 10^7}{306.8056 \cdot (345^4 - 300^4)}$$

$$= \frac{20 \times 0.35 \times 10^7}{306.8056 \times 6.072 \times 10^9}$$

$$= 5.637 \times 10^{-5} \text{ erg cm}^{-2} \text{ sec}^{-1} \text{ K}^{-4}$$

3)
$$\sigma = \frac{40 \times 0.47 \times 10^7}{306.8056 \cdot (376^4 - 300^4)}$$

$$= \frac{40 \times 0.47 \times 10^7}{306.8056 \times 11.892 \times 10^9}$$

$$= 5.141 \times 10^{-5} \text{ erg cm}^{-2} \text{ sec}^{-1} \text{ K}^{-4}$$

4)
$$\sigma = \frac{50 \times 0.58 \times 10^7}{306.8056 \cdot (404^4 - 300^4)}$$

$$= \frac{50 \times 0.58 \times 10^7}{306.8056 \times 18.102 \times 10^9}$$

$$= 5.223 \times 10^{-5} \text{ erg cm}^{-2} \text{ sec}^{-1} \text{ K}^{-4}$$

Average $\sigma = 5.17 \times 10^{-5} \text{ erg cm}^{-2} \text{ sec}^{-1} \text{ K}^{-4}$

Note: All above measurements and readings varies from instrument to instrument due to change in dimensions.

viii) The several sets of observations are taken by varying the potential difference (V) & current (I) with the help of potentiometer.

ix) The area of the plate can be calculated by measuring the radius of the disc.

SAMPLE OBSERVATIONS

The area of the copper plates = 306.8056 sq. cm.

Least Count of Thermometer = 1 °C.

S.No.	Voltage	Current	Room Temp. T °K	Mean Temp. of Thermometers T °K
1	20	0.25	300	328
2	30	0.35	300	395
3	40	0.47	300	376
4	50	0.58	300	404

RESULT

The value of Stefan's constant, with the help of the experiment is

$$\sigma = 5.17 \times 10^{-5} \text{ ergs cm}^{-2} \text{ sec}^{-1} \text{ K}^{-4}$$

Standard Value $= 5.67 \times 10^{-5}$ ergs cm^{-2} sec^{-1} K^{-4}

Percentage error = 8.8%

PRECAUTIONS

1. The readings of thermometers are taken only as stated above.
2. All the fittings should be airtight.

PARTS LIST

1. MAIN UNIT ☐
2. HEATER PLATES ☐
3. THERMOMETER (3 nos) ☐
4. CONNECTING WIRES ☐
5. INSTRUCTION MANUAL ☐