Date 16-01-2022

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"Thermal Conductivity"

Aim:- To determine the coefficient of thermal Conductivity of the given specimen of a bad Conductor by Lees disc Method.

Apparatus required:- Lees disc apparatus, steam boiler, given specimen, two Celcius thermometer, heating arrangement, stop watch and vernier - callipers.

Formula used:-

$$K = \frac{msd}{A(\theta_1 - \theta_2)} \left.\frac{d\theta}{dt}\right|_{\theta=\theta_2}$$

where $A = \pi r^2$ is the area of cross-section and d is the thickness of the given specimen.
θ_1 and θ_2 are steady state temperature of the thermometers T_1 and T_2 respectively,
m is the mass and s is the specific heat of the material of disc C. and
$\left.\frac{d\theta}{dt}\right|_{\theta=\theta_2}$ is the rate of fall of temperature of the brass disc C at $\theta = \theta_2$.

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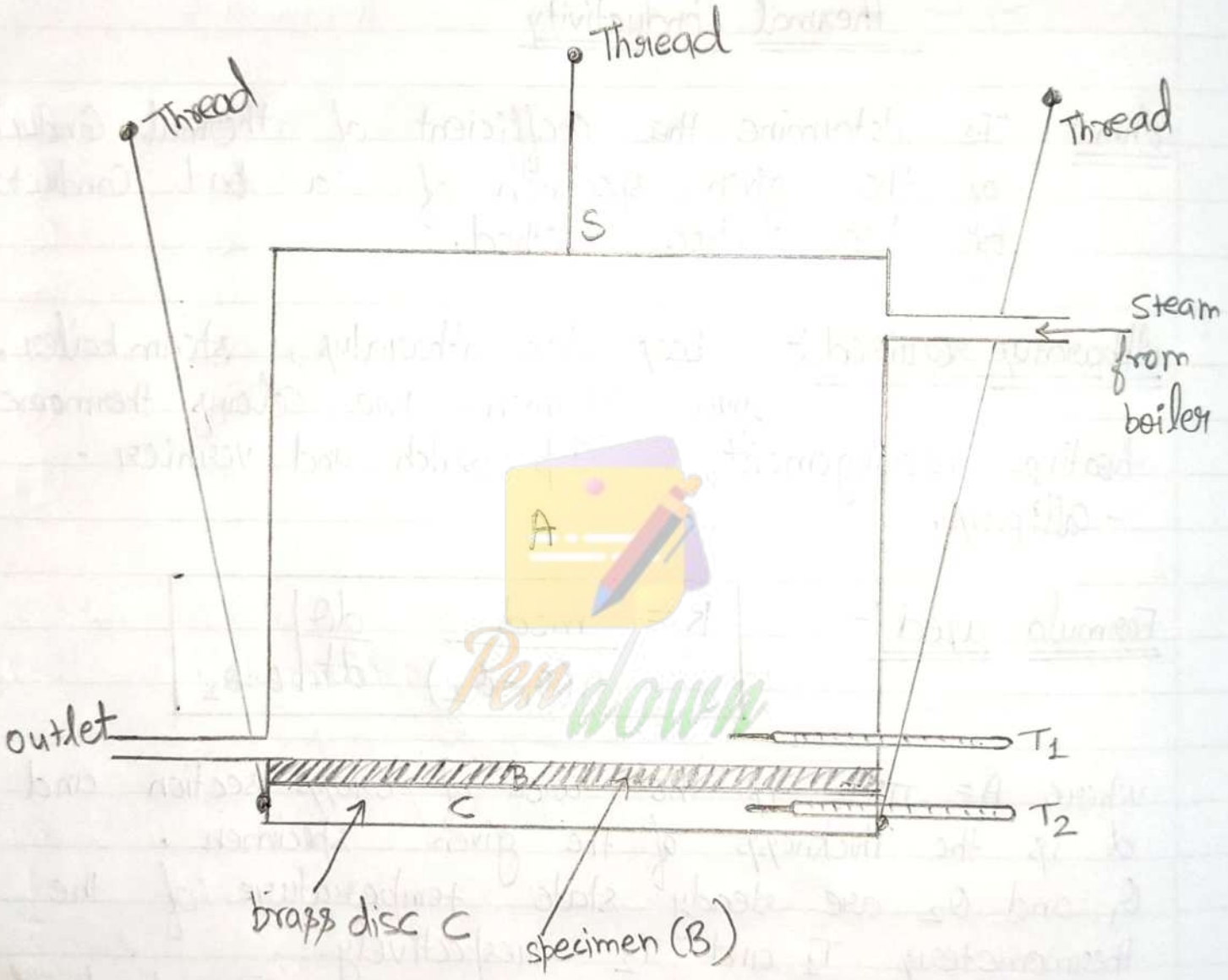

Lee Disc Setup

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Procedure:- (1) Determine the least count of vernier calliperş and meaşure the diameter ($2r$) and thickneşş d of the given bad Conductor şpecimen.

(2) Set up the apparatuş aş şhown in figure and ştream iş now paşşed through the ştream chamber.

(3) After 10 - 15 min ştart obşerving the temperatureş of the thermometerş T_1 and T_2 at about 5 min intervalş. when laşt two obşervation repeat it iş enşured that the ştready ştate haş reached. and laşt two obşervationş of the thermometerş T_1 and T_2 are the value of θ_1 and θ_2 reşpectively.

(4) As the thermometer T_1 and T_2 are very cloşe to the şpecimen, which iş a bad Conductor, the temperatureş are taken aş the temperatureş of two faceş of the şpecimen.

(5) For determining $\left.\frac{d\theta}{dt}\right|_{\theta=\theta_2}$, firşt remove the şpecimen B şo that the ştream chamber A iş in direct Contact with braşş dişc C and let it get heated till the temperature of Thermometer T_2 increaşeş by about 10°C, above θ_2.

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swich off the heater and remove steam chamber A. Place the specimen B on the Brass disc C and record the readings of the Thermometer T_2 at a regular interval of 30 sec till the temperature T_2 falls to nearly $(\theta_2 - 10)^\circ C$.

⑥ Plot the graph between Temperature of T_2 (i.e θ) vs time t, find the slope at $\theta = \theta_2$

Observations :-

- Mass of the brass disc C = 900 gm
- specific heat of the material of disc c (s) = 0.095 cal $gm^{-1} {}^\circ C^{-1}$.

T-1 Determination of the diameter and the thickness of the given bad conductor specimen B :-

Least Count of vernier calliper = 0.01 cm

S.No	Diameter of the specimen			Thickness of the specimen		
	MS (cm)	VS (div)	Total (cm)	MS (cm)	VS (div)	Total (cm)
1	11.0	5	11.05	0.5	0	0.50
2	11.0	7	11.07	0.5	2	0.52
3	11.1	0	11.10	0.5	1	0.51
			Mean = 11.07 cm			Mean = 0.51 cm

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T-2 :- Determination of steady state temperatures θ_1 and θ_2.

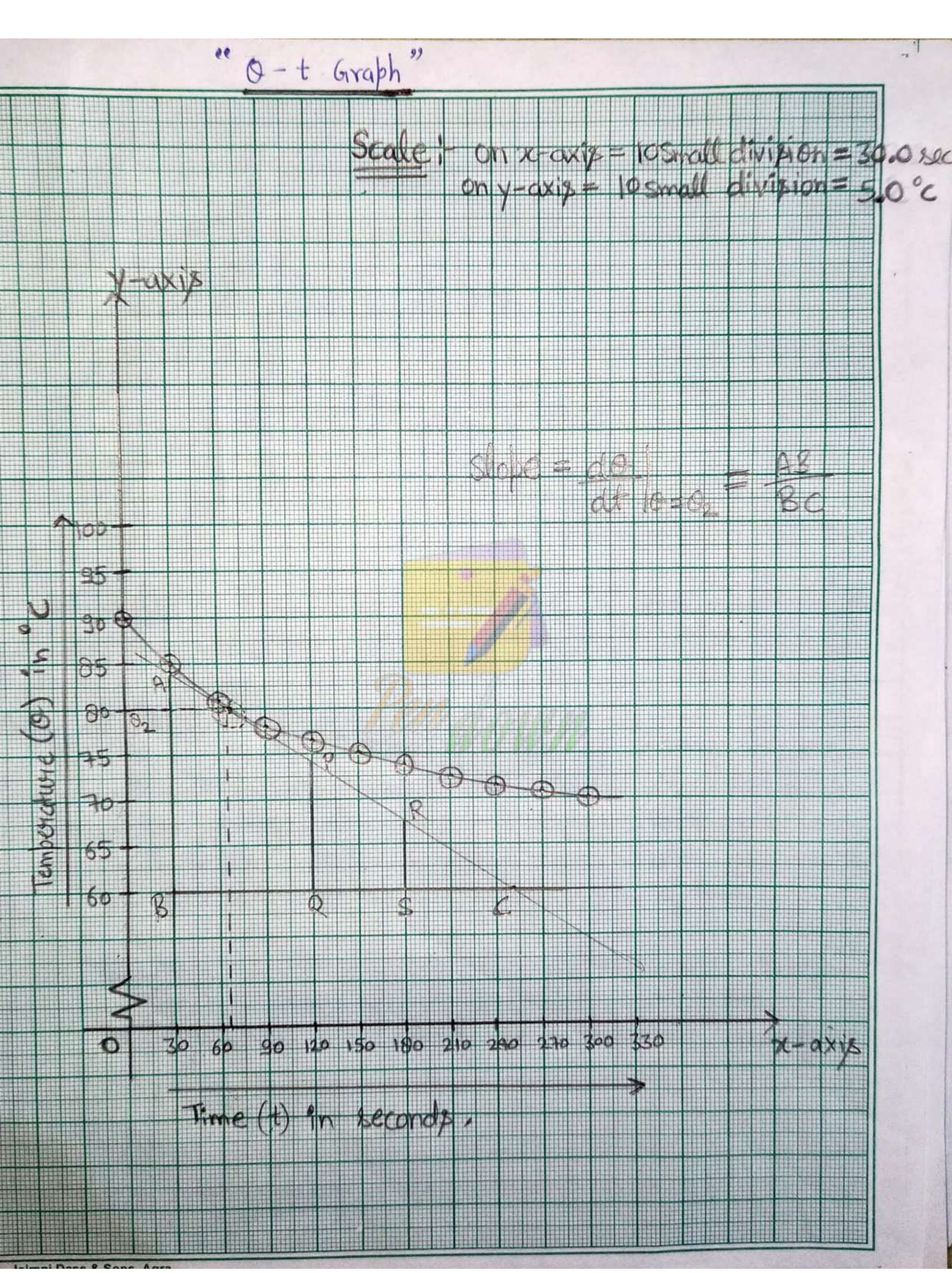
S.No	Time in minutes	Temperature of T_1 and T_2	
		θ_1 (°C)	θ_2 (°C)
①	5	51	32
②	10	87	47
③	15	96	64
④	20	96.5	73
⑤	25	96.6	78
⑥	30	96.63	80
⑦	35	96.63	80

T-3 :- Determination of $\left.\frac{d\theta}{dt}\right|_{\theta=\theta_2}$

S.No	Time t (Sec)	Temperature at T_2 θ (°C)
1	0	90
2	30	85
3	60	81
4	90	78
5	120	76.5
6	150	75
7	180	74
8	210	72.5
9	240	71.5
10	270	71
11	300	70

"θ - t Graph"

Scale: on x-axis = 1 small division = 30.0 sec
on y-axis = 1 small division = 5.0 °C



$$\text{Slope} = \left.\frac{d\theta}{dt}\right|_{\theta=\theta_2} = \frac{AB}{BC}$$

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Calculations :-

(1) For $\left.\frac{d\theta}{dt}\right|_{\theta=\theta_2}$

(a) $\left.\frac{d\theta}{dt}\right|_{\theta=\theta_2} = \frac{AB}{BC} = \left(\frac{84-60}{240.9-30.0}\right) = 0.1$

(b) $\left.\frac{d\theta}{dt}\right|_{\theta=\theta_2} = \frac{PQ}{QC} = \frac{74-60}{(240.9-120.0)} = 0.1$

(c) $\left.\frac{d\theta}{dt}\right|_{\theta=\theta_2} = \frac{RS}{SC} = \frac{67.5-60.0}{(240.9-180.0)} = 0.1$

Mean $= \frac{0.1+0.1+0.1}{3} = 0.1$

$\therefore$ slope of $\theta - t$ graph at $\theta = \theta_2 = 0.1$

(2) $\theta_1 = 96.63^\circ C$, $\theta_2 = 80^\circ C$

$m = 900\ gm$, $s = 0.095\ cal\ gm^{-1}\ ^\circ C^{-1}$

thickness $d = 0.51\ cm$

radius $r = \frac{11.07}{2} = 5.53\ cm$

$\left.\frac{d\theta}{dt}\right|_{\theta=80^\circ} = 0.1$

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$$K = \frac{msd}{\pi r^2 (\theta_1 - \theta_2)} \left.\frac{d\theta}{dt}\right|_{\theta=\theta_2}$$

$$K = \left[\frac{900 \times 0.095 \times 0.51}{3.14 \times (5.53)^2 (96.63 - 80)} \times 0.1\right] \text{cal cm}^{-1} \text{s}^{-1} {}^\circ\text{C}^{-1}$$

$$K = 2.7 \times 10^{-3} \text{ cal cm}^{-1} \text{s}^{-1} {}^\circ\text{C}^{-1}$$

Result:- The Thermal Conductivity of the material of given specimen is 2.7×10^{-3} cal $cm^{-1} s^{-1} {}^\circ C^{-1}$.

Precautions:-

(1) Value of slope by making tangent to the curve should be done very carefully by taking at least 3 points and get 3 slopes and compare them will get more accurate slope (by taking mean of them).

(2) Since room temperature might change during the course of experiment, so the experiment should be completed quickly.

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