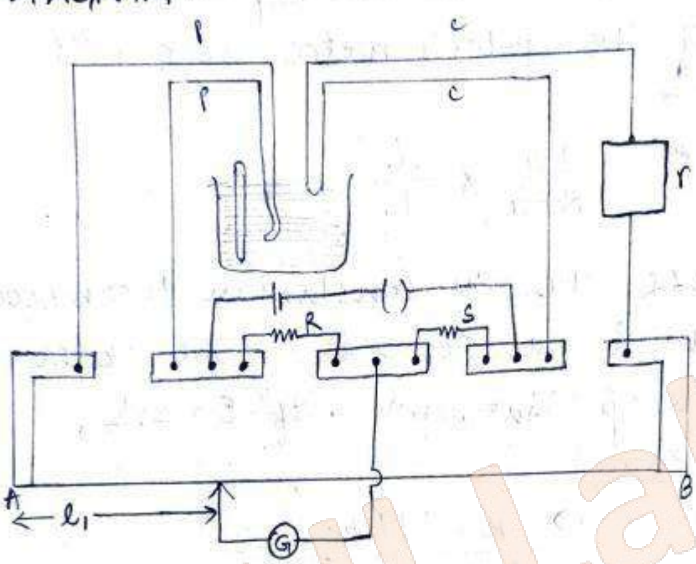
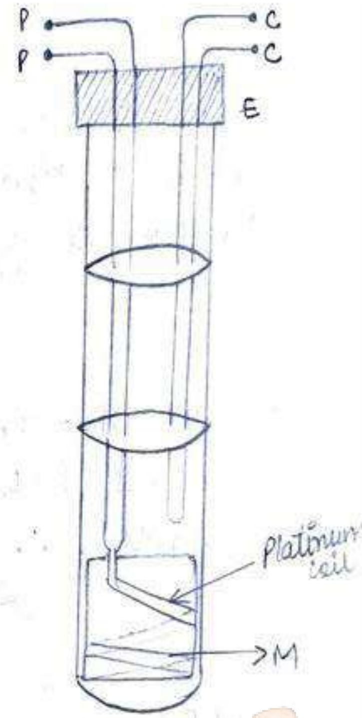
To determine the temperature coefficient of resistance for platinum using a Carey Foster's bridge and a platinum resistance thermometer

by Platinum resistance

DIAGRAM:





OBSERVATIONS: Ice: $T_1 = 0°C$ Water (normal): $T_2 = 26°C$ Hot water $T_3 = 100°C$

for Ice →

fractional resistance (Ω)	l_1(cm)	l_2 (cm)	$(l_2 - l_1)$ cm.
1	15	64.9	49.6
1.1	18	62.6	44.6
1.2	20.5	58.9	38.4
1.3	25.3	57.6	32.3
1.4	27.8	54.7	26.9
1.5	30.3	51.3	21.6
1.6	35.5	47.7	14.2
1.7	36	45.9	5.5
1.8	38	42	4
1.9	39.3	40.1	0.2
2.0	41	38	-3

AIM: To determine the temperature coefficient of resistance for platinum using a Carey Foster's bridge and a platinum resistance thermometer.

APPARATUS: Platinum Resistance thermometer, Carey Foster's Bridge, galvanometer, A Battery, two Resistance boxes, fractional resistance box, a thermometer and a simple key.

THEORY: Platinum Resistance thermometer is based on the principle that the resistance of pure platinum wire increases with its temperature according to the formula –

$$R_T = R_0(1 + \alpha T + \beta T^2)$$

where, R_0 = Resistance of wire at 0°C

R_T = Resistance of wire at T°C

and α, β are constants.

A short length ABC of platinum wire is doubled and wound on a mica frame and placed at the bottom of a thin porcelain tube M. Its ends A and C are soldered to long copper lead wires. The two wires are taken through holes in mica discs marked D in fig. and are attached at the top to the terminals marked PP. Two additional identical copper wires joined at the bottom are placed by the side of PP. They are marked CC and are called 'compensating' wires as these wires are connected to compensate for the resistance of the other leads connected.

for Normal water. room temperature

fractional resistance (Ω)	l_1 (cm)	l_2 (cm)	(l_2-l_1) cm
1	16	76.5	60.5
1.1	19.8	74.9	56.9
1.2	20.8	78.2	51.9
1.3	23	69.5	46.5
1.4	25.6	67	41.4
1.5	28	64.3	36.3
1.6	30.3	61.9	31
1.7	33.7	59	25.3
1.8	36.2	56.4	20.2
1.9	38.4	52.5	15.1
2.0	42.6	51.2	8.6

for Hot-water

fractional resistance (Ω)	l_1 (cm)	l_2 (cm)	(l_2-l_1) cm
1	0.7	90.5	89.8
1.1	2.8	89	86.2
1.2	5.6	87.9	82.1
1.3	8.1	85.5	77.4
1.4	10.6	83	72.4
1.5	16	79.8	63.8
1.6	17.5	77.3	59.8
1.7	21.7	74.6	52.9
1.8	23.6	72	48.4
1.9	27.6	69.4	41.8
2.0	28.4	67.4	38

to the platinum wire.

Since β is very small, we can put the above relation as $R_T = R_0(1+\alpha T)$ without making serious error.

'α' is called the temperature coeff. of resistance for Platinum.

We can define the temperature coefficient of resistance for a material as the increase in the resistance of a wire of that material per unit resistance per degree rise in temperature. It is measured in units per degree centigrade ($^\circ C^{-1}$)

If R_1 and R_2 represent the resistance of the platinum resistance at T_1 and T_2 °C respectively, then

$$R_1 = R_0(1+\alpha T_1)$$

$$R_2 = R_0(1+\alpha T_2)$$

$$\frac{R_1}{R_2} = \frac{1+\alpha T_1}{1+\alpha T_2}$$

$$R_2(1+\alpha T_1) = R_1(1+\alpha T_2)$$

$$(R_2 - R_1) = \alpha(T_2 R_1 - T_1 R_2)$$

$$\left[\alpha = \frac{R_2 - R_1}{T_2 R_1 - T_1 R_2}\right]$$

RESULT: The temperature coefficient of resistance for platinum using platinum resistance thermometer is given by 0.00495 $^\circ C^{-1}$

PRECAUTIONS & SOURCES OF ERROR:

1. The balance pt. should be determined only when the temp. acquired by the platinum thermometer is steady. This will be indicated by the constancy of the balance pt. in the same position of the bridge-wire.

CALCULATIONS :-

from Graph, $R_1 = 1.87\ \Omega$ $T_1 = 0°$

$R_2 = 2.18\ \Omega$ $T_2 = 26°$

$R_3 = 2.74\ \Omega$ $T_3 = 100°$

Now, we know, $\left(\alpha = \frac{R_2 - R_1}{T_2 R_1 - T_1 R_2} \right)$

(I) $\alpha = \frac{R_2 - R_1}{T_2 R_1 - T_1 R_2} = \frac{2.18 - 1.87}{26 \times 1.87 - 0 \times 2.18}$

$= \frac{0.31}{48.62} = \underline{0.00638}$

(II) $\alpha_2 = \frac{R_3 - R_2}{R_2 T_3 - R_3 T_2} = \frac{2.74 - 2.18}{2.18 \times 100 - 2.74 \times 26} = \frac{0.56}{146.76}$

$= \underline{0.00382}$

(III) $\alpha_3 = \frac{R_3 - R_1}{R_1 T_3 - R_3 T_1} = \frac{2.74 - 1.87}{1.87 \times 100 - 2.74 \times 0} = \frac{0.87}{187}$

$= \underline{0.00465}$

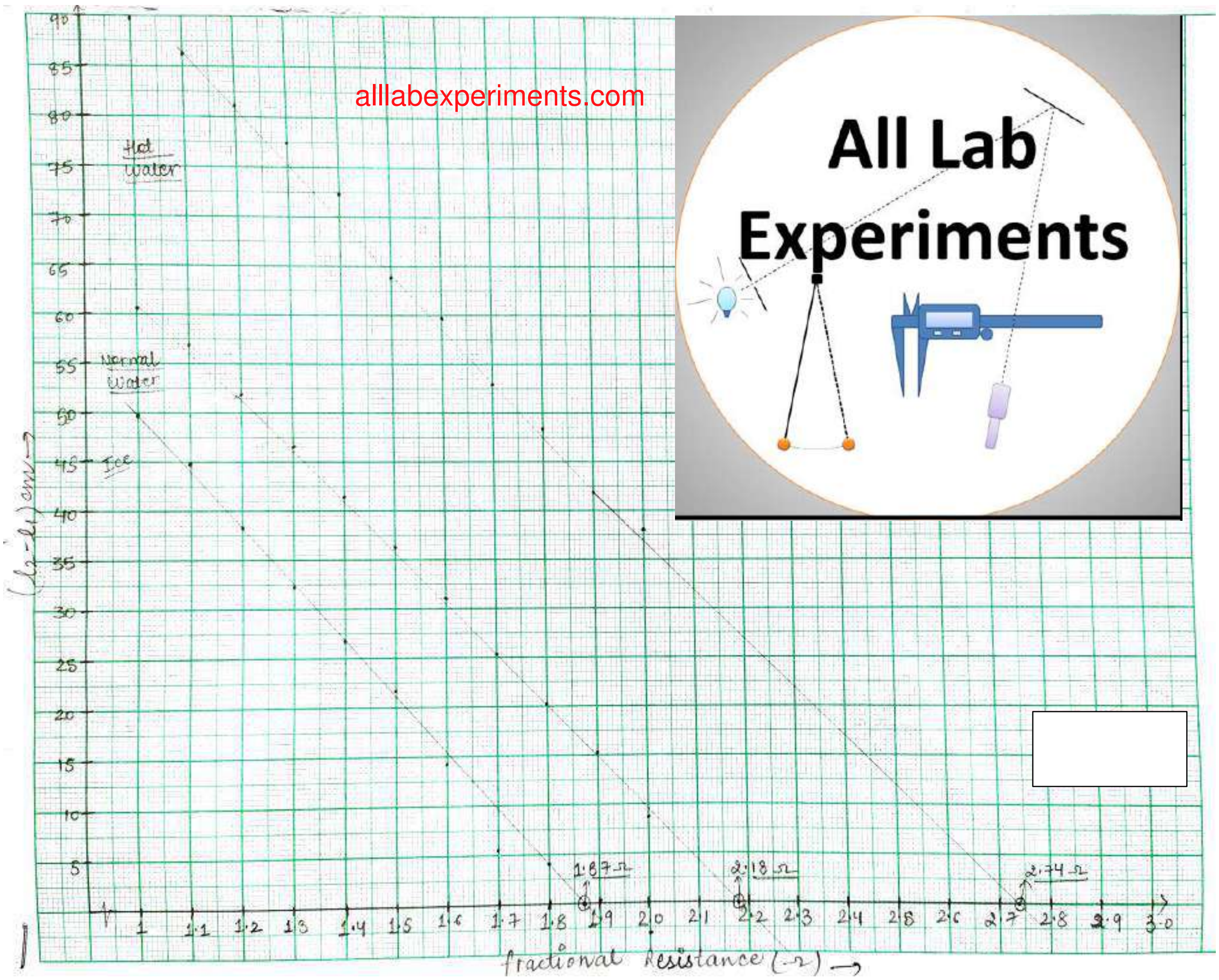
Mean $\alpha = \frac{\alpha_1 + \alpha_2 + \alpha_3}{3}$

$= \frac{0.00638 + 0.00382 + 0.00465}{3}$

$\alpha = \underline{0.00495}\ °C^{-1}$

RESULT:

The temperature coefficient of resistance for platinum using platinum resistance thermometer is given by $\underline{0.00495\ °C^{-1}}$


Hot Water
Normal Water
Ice
(l2 - l1) cm →
Fractional Resistance (Ω) →
1.87 Ω
2.18 Ω
2.74 Ω

2) The difference between P and Q should not be more than the resistance of the bridge-wire.

3) For Bridge to have high sensitivity, the resistances of the four arms should be of the same order.

4) The ends of the connecting wires should be clean and all connections should be right.

All Lab Experiments

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