To study the variation of Thermo-E.m.f of a Thermocouple with Difference of Temperature of its Two Junctions:

- **Construction of thermo-couple**: A copper(Cu)-constantan(Cn) couple is employed for this experiment. To prepare this couple, three pieces of wires, each of one meter long are taken, of which one is of Cn, while the other two are of copper. The two ends of Cn wire are cleaned and are joined by twisting with one end of each of the copper wires. Then these junctions are soldered with minimum amount of solder covering a length of about 2-3 mm of each junction. Two glass tubes T_1 and T_2 (figure below, Fig. 1) are introduced in the copper wires to be sure that the metals touch at the junctions only.
- **Circuit Connections**:

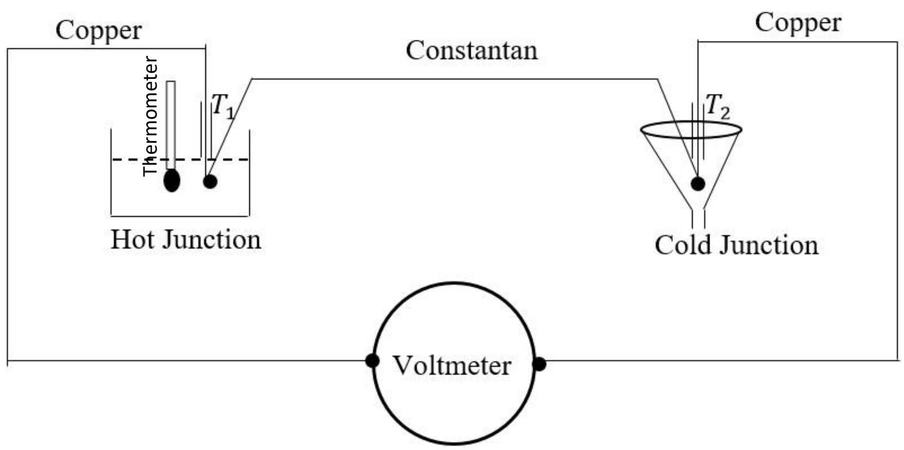

Figure 1

Ice is poured in the funnel (see Fig. 1) to cool the right hand junction to 0°C. The left hand junction is dipped inside a pot filled with water. The water temperature can be varied using a heater controllably and the corresponding temperature should be measured using a thermometer placed near the junction inside the water (see the figure). To measure the thermo-e.m.f a voltmeter (that can measure millivolt) is used.

- **Theory**: When one junction of a thermo-couple is kept at 0°C while its other junction is maintained at a higher temperature, thermo-e.m.f e will be developed in the couple. Magnitude of the thermo-e.m.f depends upon the temperature difference between the two junctions (here on the temperature of the hot junction only as the cold junction temperature is 0°C). Variation of the thermo-e.m.f can be studied by plotting the measured thermo-e.m.f using the voltmeter with temperature of the hot junction (i.e., with the temperature difference of its two junctions) measured using the thermometer. The thermo-electric power at a temperature θ°C is defined as $P = \frac{de}{dt}|_{t=\theta}$, which can be found by drawing a tangent to the thermo-e.m.f versus temperature curve at the point corresponding to θ°C of the hot junction.
- **Procedure**:
    - The setup is constructed as described before.
    - To create the cold junction, ice cubes are smashed and poured in the funnel ensuring that the junction is well covered by the ice so that the junction temperature becomes 0°C.
    - Now a heater should be turned on to heat up the water in the left hand side pot to controllably increase the temperature of the hot junction.

- The thermometer in the pot should be used to measure the corresponding temperature.
- The connected voltmeter should be used to measure the generated thermo-e.m.f.
- The e.m.f should be recorded for temperatures from $25^{\circ}\mathrm{C}$ to $85^{\circ}\mathrm{C}$ in a step of $5^{\circ}\mathrm{C}$ (use the *Table 1*).
- Replace the hot water by cold water and repeat the measurement for three times and take the average.
- Now the recorded thermo-e.m.f (e) should be **plotted** against the measured temperature of the hot junction on graph paper.
- Now to calculate the thermo-electric power at a temperature (say $\theta = 5^{\circ}\mathrm{C}$), the slope of the tangent at that temperature point on the thermo-e.m.f versus temperature curve should be calculated (as described in the theory section). Follow the *Table 2*.

Table 1 (*Table to produce Thermo-e.m.f versus temperature graph*):

Temperature (°C)	Thermo-e.m.f (mV)			Mean Thermo-e.m.f (mV)
	1st Set	2nd Set	3rd Set	
25				
30				
…	…	…	…	…

Table 2 (*Table to calculate the thermo-electric power at the temperature* $\boldsymbol{\theta = 40^{\circ} C}$):

Temperature (°C)	Δt (°C)	Δe (mV)	Δe (μV)	$P = \frac{\Delta e}{\Delta t}$ (μV/°C)
40	…	…	…	…