# Determination of the melting point of a solid with a thermocouple:

- **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**:

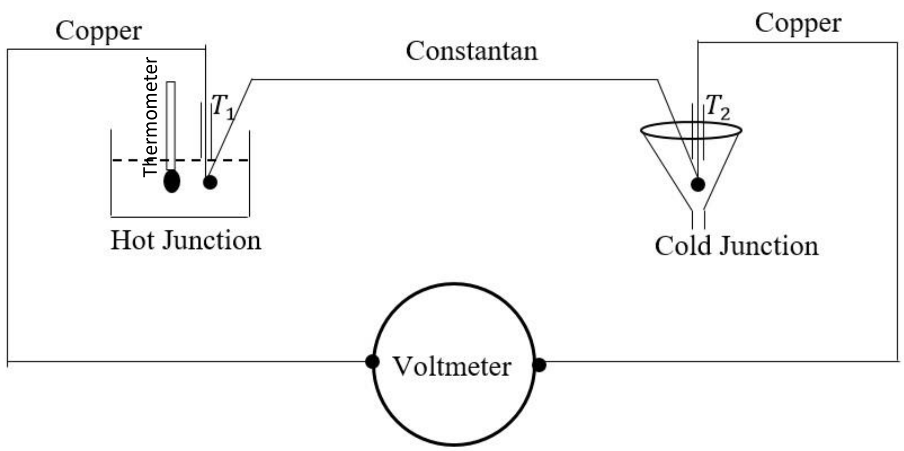


*Figure 1*

Ice is poured in the funnel (see Fig. 1) to cool the right hand junction to $0^{\circ}$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 $0^{\circ}$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 $0^{\circ}$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-e.m.f $e$ versus temperature curve should be approximately linear over around up to $90^{\circ}$C. (see Fig. 2) This plot can be used as a calibration curve, and later the hot junction of the thermo-couple can be used as a thermometer. If the hot junction is inserted into a body, a thermo-e.m.f ($e_{hot}$) will be generated in the thermo-couple, and the temperature ($\theta_{hot}$) corresponding to that thermo-e.m.f can be found from the calibration curve. This thermo-couple thermometer thus also can be used to determine the melting point of a solid following the procedure below.

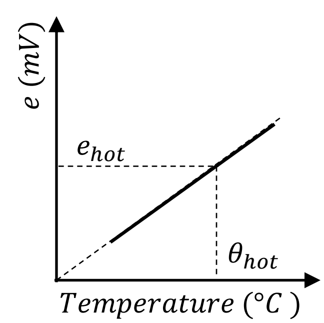


*Figure 2: Calibration curve*

- **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 $0^{\circ}\mathrm{C}$.
    - 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 a graph paper to create the **calibration curve**.
    - To measure the melting point of a solid, the hot junction should be inserted into the solid (usually in a powder form) present inside a test-tube immersed into a water bath (see Fig. 1) that can be controllably heated up using a heater.
    - The thermometer should be removed from the water bath as we want to use the thermo-couple as a thermometer.
    - Now the heater should be turned on and the e.m.f should be recorded each after 30 seconds until the solid gets melted completely. Follow the *Table 2*.
    - The thermo-e.m.f (mV) should be plotted against the time (s), which should have a flat region (almost parallel the time axis). The thermo-e.m.f ($e_{melt}$) corresponding to the flat region represents the melting process of the solid.
    - The corresponding temperature should be determined from the calibration curve.

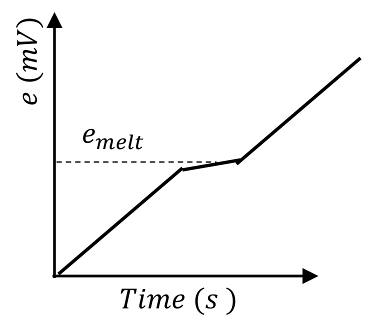

*Figure 3: Melting curve*

**Table 1 (*Table to produce Thermo-e.m.f versus temperature graph, i.e., the calibration curve*)**:

| 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 measure the melting point in* °C)**:

| Time ($s$) | Thermo-e.m.f (mV) | $e_{melt}$(mV) | Melting point in °C |
|---|---|---|---|
| 0 | … | … | … |
| 30 | | | |

| | | | |
|---|---|---|---|
| 60 | | | |
| … | | | |