كلية التربية
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1. Describe the principle, construction and working of a thermo electric thermometer..

---------- **Solution** ----------

Thermoelectric Thermometer

The principle underlying a thermoelectric thermometer is that when one junction of two different metals such as iron and copper is heated keeping the other cold an emf is generated and a current flows through the circuit, see Fig. (6). This is known as ***Seebeck effect***. The magnitude of the emf generated is proportional to the temperature of the hot junction if that of the cold junction is kept constant. Variation of thermo emf with temperature is given from the expression:

$$E = \alpha T + \beta T^2$$

where T is the temperature of the hot junction, α and β are constants. It has been found that for temperature up to $300^{o}C$, copper constantan and iron constantan are good as they give thermo emf of the order of 40 to 60 microvolt per degree temperature difference between junctions.

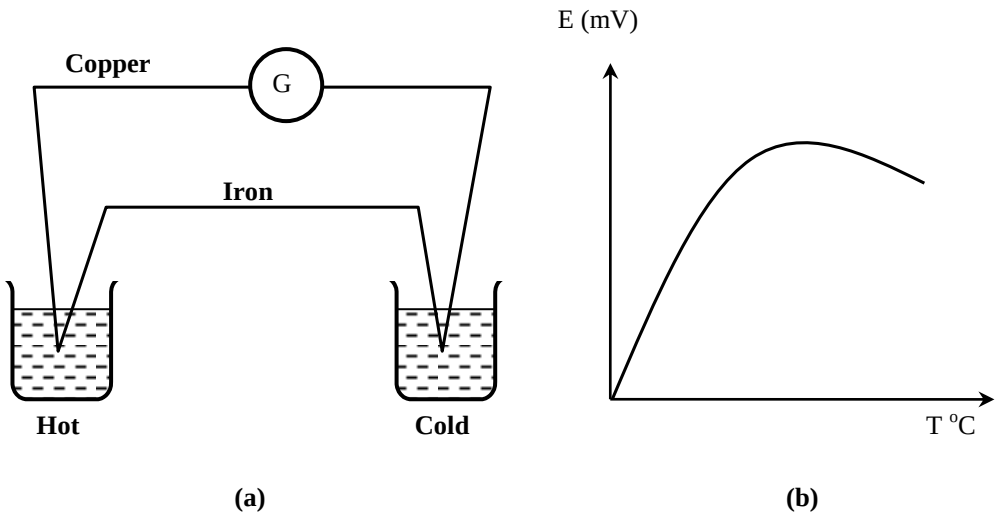

Fig. (6): (a) Thermocouple thermometer. (b) Thermocouple characteristic

The construction details of a simple thermocouple thermometer (or thermoelectric thermometer) are shown in Fig. (7). It consists of a tube B made of silica. Inside the tube a junction A obtained by electrical welding the two wire is kept. The junction A is called the hot junction as it will measure the unknown temperature. The portion of the wires near the hot junction A are insulated with capillary tubes C of hard glass.

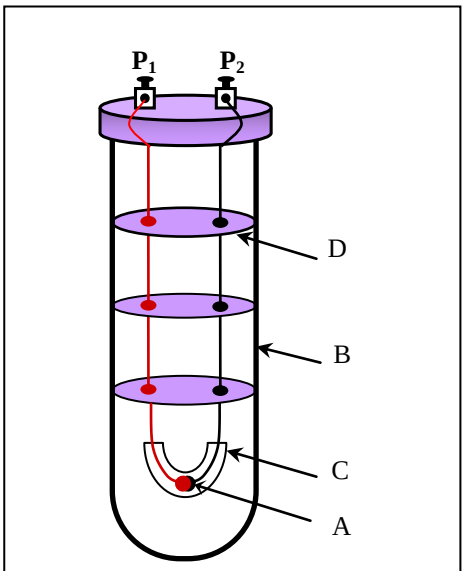

Fig. (7): Thermocouple thermometer

These two wires are then passed through mica disks D closely fitted in the tube B and attached to terminals P_1, P_2 fixed on the cap closing the mouth of tube. To these terminals long wire of the same metals are also

connected to form a cold junction being immersed in melting ice at $0^{o}C$ at a fairly distance place from hot junction.

In order to measure the temperature of a system following method is used. Firstly, a calibration curve of thermometer is drawn between temperature and emf. This is obtained by putting cold junction at ice point and increasing the temperature of hot junction and recording the corresponding thermo emf. Then the hot junction is kept in contact with the system whose temperature is measured and cold junction is again kept at ice point. The thermo emf is noted and the corresponding temperature is read from the calibration curve.

The thermocouple thermometer has the advantage of its suitability for measuring the rapidly varying temperatures as it has small thermal capacity. It has a wide range from $-200^{o}C$ to $1000^{o}C$.

2. Describe a method to determine the specific heat of a solid by the method of mixtures

---------- **Solution** ----------

Specific Heat of Solids (Mixture Method)

Mixture method is the one most commonly used in the laboratory for determining the specific heat of solids. The apparatus consists of two parts, the heater H and the calorimeter C, see Fig. (3). The heater consists of two coaxial cylinders, the annular space between them being supplied with a steady flow of steam. The top of the air chamber (inner one) is closed with a cork while the bottom by a trap door through which the solid may be dropped into the calorimeter. The calorimeter is a copper vessel placed in a wooden box packed with wood to reduce loss of heat by conduction. The calorimeter is provided with a copper stirrer and a sensitive thermometer.

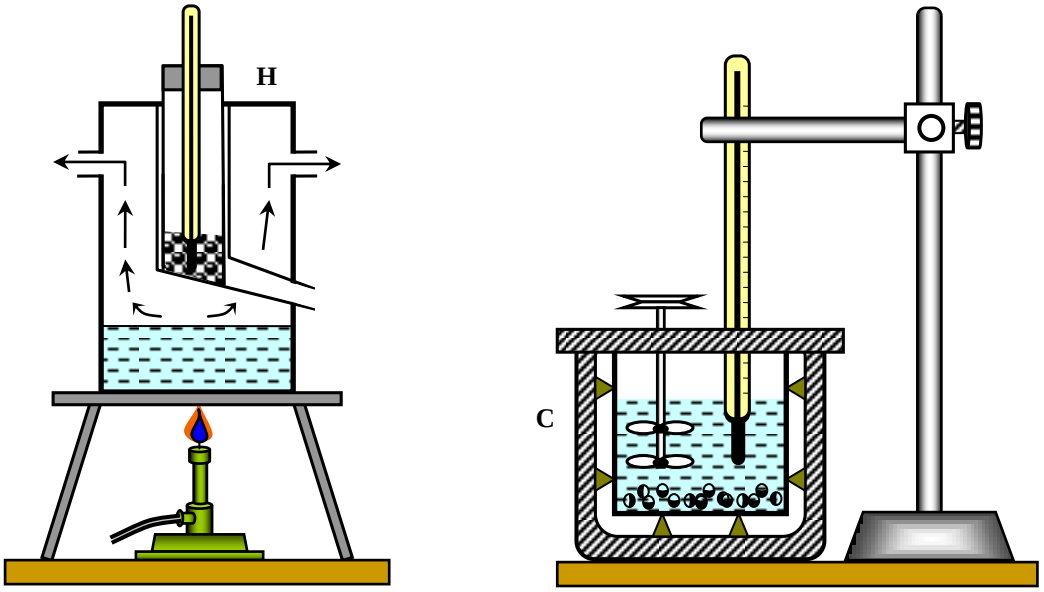

Fig. (3): Determination of specific heat of a solid by mixture method

The solid, in the form of a small pieces, is weighted and suspended inside the heater by a thread passing through the cork. Steam is passed

through the heater from a boiler, so that the solid may be heated without actual contact with steam or water. While the solid is heated, the empty dry calorimeter, with the stirrer is weighted. Water is taken in the calorimeter and the calorimeter and contents are weighted again. The mass of water taken is then readily found. The calorimeter is placed back inside the wooden box and the temperature of the water is noted.

When the solid has attained the steady maximum temperature, the calorimeter is pushed under the trap door of the heater and the solid dropped into the calorimeter. The contents of the calorimeter are well stirred and the highest temperature reached is noted.

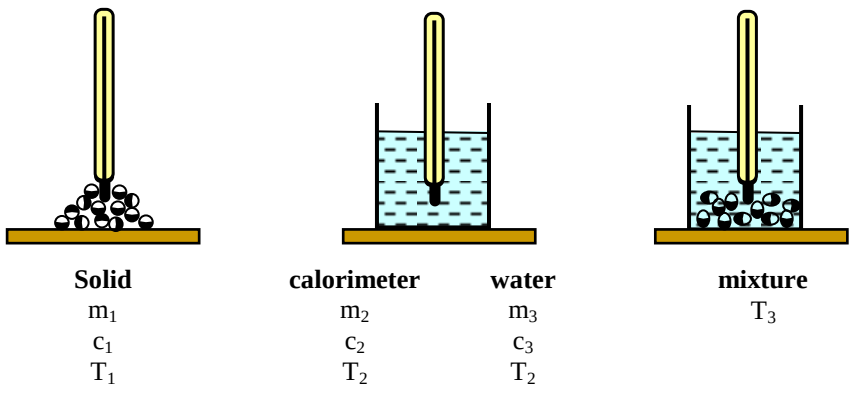

Fig. (4): Data taken in the mixture method

Suppose c_1 is the specific heat of a given solid. m_1 grams of the solid at $T_1\,^oC$ is added to m_3 of water at $T_2\,^oC$ in a calorimeter whose mass is m_2 and its specific heat is c_2. Let $T_3\,^oC$ be the final temperature of the mixture, see Fig. (4). By equating the heat lost by the solid Q_s to the heat gained by the calorimeter and water $(Q_c + Q_w)$ we get

$$\text{Heat lost by solid} = \text{Heat gained by (calorimeter + water)}$$

$$Q_s = Q_c + Q_w$$

$$m_1c_1(T_3 - T_1) = (m_2c_2 + m_3c_3)(T_3 - T_2) \qquad (8)$$

from which c_1 can be determined.