THERMOCOUPLE.

AIM: Study of a thermocouple and plot a graph between thermo emf and temperature of hot junction.

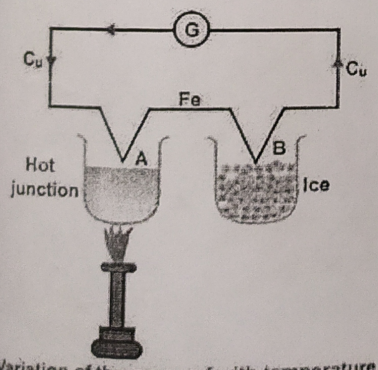
APPARATUS REQUIRED:-Digital D.C Microvoltmeter Thermometer (0-360^{0}C), Sand bath ,Beaker, Funnel ,Copper-Constantan Thermocouple ,Retort stand with ring, Tripot stand ,Wooden stand, Connecting wires, Ice .

THEORY:-

Seeback effect

If two rods of different substances say constantan and copper be soldered at the ends and if one of the junctions be kept at a constant temperature, say, in melting ice (at 0^{0}C)while the other be placed in a sand bath whose temperature is gradually raised, a sensitive galvanometer included in the circuit indicates an increasing current. This is the thermo- electric current and the two rods form a Thermo-couple. This is illustrated in Fig1.

The strength of the current depends upon the materials forming the couple and on the difference of temperatures between the two junction.



Variation of thermo e.m.f with temperature

Fig-1

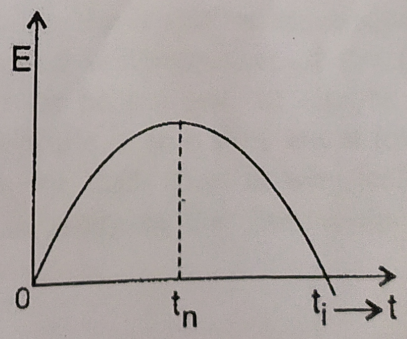


Fig-2

As this temperature-difference is gradually increased the current first increases becomes a maximum for a given temperature of the hot junction and then begins to decrease with a further rise in its temperature. The temperature of hot junction for maximum current is called the Neutral temperature it is independent of the temperature of cold junction. This is illustrated in fig 2.

As the current depends upon the resistance of the circuit and resistance changes with a change in temperature, it is usual to measure the emf developed in the circuit not the current.

When measuring temperatures with a thermocouple care should be taken to see that the neutral temperature for the pair is remote from the temperature-range in use. With a couple of copper-constantan temperature upto300^{0}C can be measured. The couple develops an e.m.f. about 15millivolts at 300^{0}C and the temperature e.m.f. curve is practically linear.

For measuring temperatures, the hot junction is brought to various temperatures and the corresponding thermo e.m.f.is determined for every temperature. A curve is plotted between temperature and e.m.f. Any unknown temperature (within this range) can be determined from the curve.

Peltier effect:

If instead of establishing a difference of temperatures between the junctions, a current be sent through the circuit in the same direction in which the thermoelectric current was flowing, the hot junction cools down while the cold junction is heated up due to the evolution of heat there. While in joule heating heat is produced throughout the circuit and the process is irreversible, in peltier-heating heat is produced (or absorbed) only at the two junction and the process is reversible.

Thomson effect:

A difference of potentials exists along the length of an unequally heated metal rod, due to the unequal concentration of the free electrons at the various points of the heated rod. In copper the hotter parts are at higher potentials while in iron they are at lower potentials. Thomson effect is zero for lead. That is why lead is taken as second element or base in studying the thermo-electric behavior of various metals.

PROCEDURE—

1.Make the arrangement as shown in Fig3

2. Heat the sand bath with hotplate and note down the reading of temperature (say at interval of 5^0)correspondingly also note down the readings of Digital Microvoltmeter.

3. Put out the hotplate and note the readings while cooling .

4. Take mean of Digital Microvoltmeter readings during increasing temperature and decreasing temperature at various temperatures

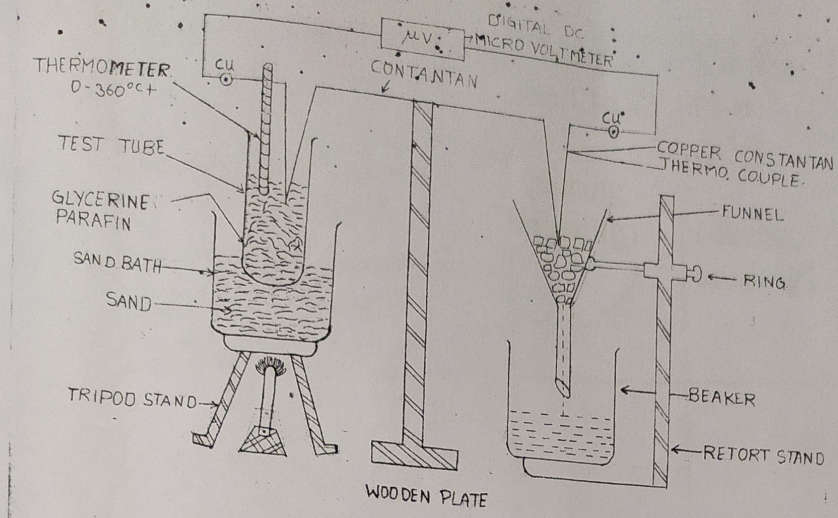


Fig-3

5. Plot a curve between temperature(along X-axis)corresponding to thermo e.m.f. developed at various temperature (along the X-axis). It should be straight line. This is illustrated in Fig.4

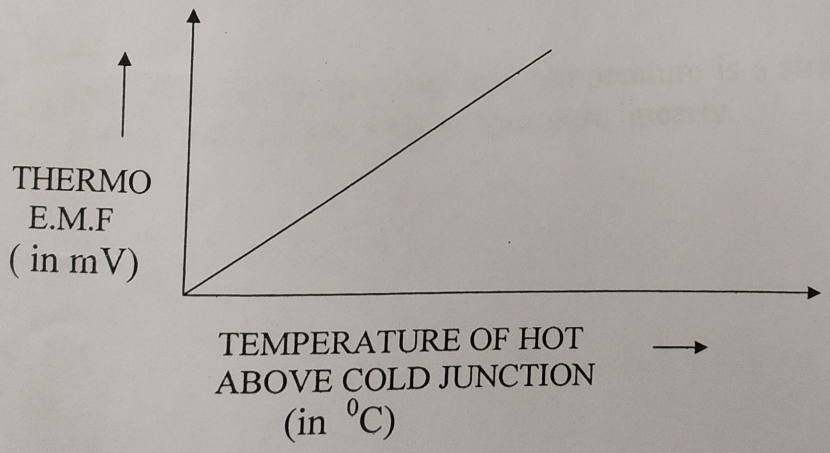


Fig-4

OBSERVATION TABLE

Temperature of cold junction = ^{0}C

S.No	Temperature of Hot Junction		Thermo Emf (μV) (during heating)	Thermo Emf (μV) (during cooling)	Mean E.M.F. (μV)
	As shown by thermo-meter (in ^{0}C)	Above cold junction (in ^{0}C)			

Result---

The graph between thermo emf and temperature is a straight line. Hence thermo emf varies with temperature linearly.

THERMOCOUPLE

1) A thermocouple is consists of

Thermocouples consist of two wire legs made from different metals. The wires legs are welded together at one end, creating a junction. This junction is where the temperature is measured. When the junction experiences a change in temperature, a voltage is created.

2) Why is thermo emf developed?
The concentration of electrons at the interface of the two metals is not the same. Thus electrons from the metal with higher electronic concentration are transferred to that with lower concentration and so a contact potential difference is created. When one junction is heated, its contact potential becomes greater than that of the cold junction and so a thermo emf is developed.

3) What is Seeback effect ?

The Seebeck effect is a phenomenon in which a temperature difference between two dissimilar electrical conductors or semiconductors produces a voltage difference between the two substances.

4) What is Peltier effect?
It is an effect where heat is given out or absorbed when an electric current passes across a junction between two materials.

5) What is Thomsom effect ?
Whenever a current is allowed to pass through an unequally heated conductor, there is evolution or absorption of heat in the conductor depending on the direction of the current.

6) What is neutral temp.
It is the temp of hot junction at which thermo emf is maximum.

7) What is temp of inversion ?
It is the temp at which the thermo emf is reversed or its value is zero.

8) Can thermocouple be used for supplying electricity for different purposes?
No, the power developed in this case is so small that it cannot be used as a source of energy.

9) What is the order of thermo emf generated in copper-constantan thermo couple. Can an ordinary voltmeter be used to measure the thermo-emf.?
It is about 40 microvolt/^{0}C. No, micro voltmeter is required.

10) Is the thermo emf vs temp. curve linear?
No. It is parabola. For a small range of temp. it is fairly linear.

11). Example of different type of thermocouple.
Iron-Copper, Antimony- Bismuth

12) A Thermocouple is used

a)A Thermocouple is a sensor used to measure temperature. It is also used in thermopiles for the detection and measurement of heat radiation.

b) To measure the temp. at a point.

c) Thermocouples are used in many industrial, scientific, and OEM applications. They can be found in nearly all industrial markets: Power Generation, Oil/Gas, Pharmaceutical, BioTech, Cement, Paper & Pulp, etc. Thermocouples are also used in everyday appliances like stoves, furnaces, and toasters.

Thermocouples are typically selected because of their low cost, high temperature limits, wide temperature ranges and durable nature.

and e.m.f. Any unknown temperature (within this range) can be determined from the wave.

study time

Teacher's Signature :_____

Observation Table

S.NO	Temp. of Heat Junction		Thermo EMF(μV) (during heating)	Thermo Emf(μV) (during cooling)	Mean EMF (μV)
	As shown by thermometer (in °C)	Above cold junction (in °C)			
1.	70	70	1·5	1·7	1·6
2.	80	80	1·7	2	1·8
3.	90	90	1·8	2·2	2
4.	100	100	1·9	2·5	2·2
5.	110	110	2·1	2·7	2·4
6.	120	120	2·3	2·9	2·6
7.	130	130	2·5	3·1	2·8
8.	140	140	2·8	3·2	3
9.	150	150	3	3·5	3·2
10.	160	160	3·3	3·6	3·4

Date_____