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Seebeck effect & Peltier effect

* Seebeck effect — If a rod of iron is welded to two pieces of thick copper wires at A and B, and the free ends of the copper wire are connected to a sensitive galvanometer, then the galvanometer shows a deflection if one of the junctions, say A is kept cold and the other, say B, is heated as shown in Fig. The current flows from copper to iron at the hot junction B. This current is called thermo-electric current and the arrangement is known as thermo-couple. The production of emf by a thermo-couple when one of the junction is heated keeping the other cold is known as Seebeck effect.

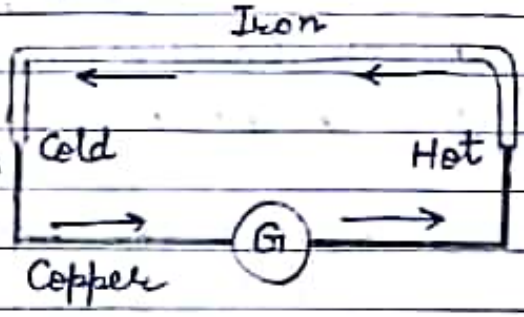

Fig. 1

The e.m.f generated depends upon:
(i) the pair of metals forming the thermo-couple.
(ii) the temperature difference between the two junctions.

· Effect of temperature :- If the end A is kept cold and the temperature of the junction B is slowly increased the thermodynamic current continuously increases as shown in Fig. 2. For

small difference of temperature, the thermo-e.m.f is proportional to temperature. For large difference of temperature the e.m.f first increases and for a certain temp. of the hot junction it becomes a maximum. This temp. is known as neutral temperature and is defined as that temperature of the hot junction at which maximum current flows. It is constant for a given couple and depends upon the pair of metals chosen but is independent of the temp. of the cold junction. For example, the neutral temperature for Cu-Fe thermocouple is 270°C whatever the temp. of the cold junction may be.

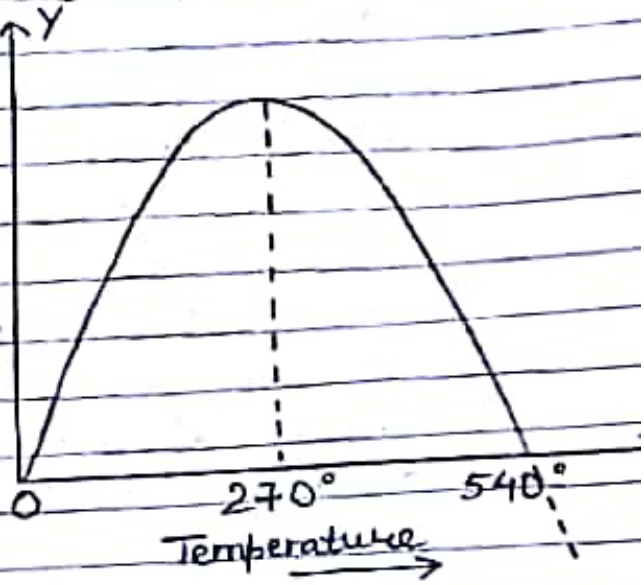

Fig. 2

Temperature of inversion :- If the temp. of the hot junction is further increased the thermo-electric current (or e.m.f) decre and finally becomes zero at a temp. know as the temperature of inversion. Th temperature of inversion is as much ab the neutral temp. as the neutral temp. a above that of the cold junction. If cold junction is at 0°C the temp. of inversion is 540°C but if the temp of col junction is 50°C the temp. of inversion

490° for Cu-Fe couple.

If the temp. is further increased the thermoelectric current increases in the opposite direction as shown in Fig 2.

* Peltier effect — Peltier effect is the complementary phenomenon to Seebeck effect. Consider a Cu-Fe thermo-couple in which a battery is placed so as to send a current from copper to iron at the junction B and from iron to copper at the junction A. It is found that heat energy is absorbed at the junction B and this junction is therefore, cooled. Heat energy is evolved at the junction A and this junction is heated.

This evolution or absorption of heat energy at a junction of a thermo-couple when a current is passed through it is known as Peltier effect.

A comparison with Fig. 1 reveals that in order to send a thermo-electric current in the same direction the junction B (at which heat energy is absorbed in this case and is cooled) must be heated and the junction A (at which heat energy is evolved in this case and is heated) must be kept cold.

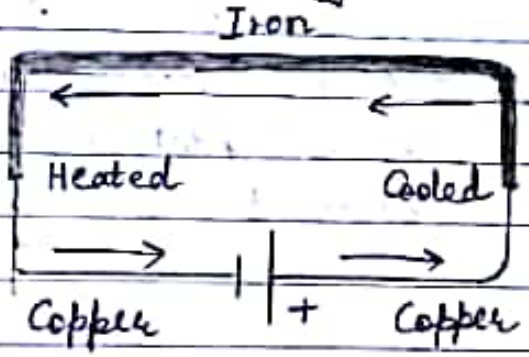

Fig. 3

The existence of Peltier effect can be explained on the basis of electron theory. The metals contain free electrons which may be considered as moving about like the molecules of a gas. When dissimilar metals are joined, there will be a flow of electrons from one metals which has a large no of electrons per unit volume, to the other having a smaller electron density. The flow continues until a potential difference high enough to prevent any further movement of electrons is established.

When copper and iron are placed in contact the potential of iron is above that of copper. If a current is passed from a battery as shown, then at B current flows from copper to iron i.e from lower potential to higher potential and hence energy is required for the purpose. This is absorbed from the junction which, therefore, is cooled. At A current flows from iron to copper i.e, from higher potential to lower lower potential and thus energy is given out so that the junction A is heated.