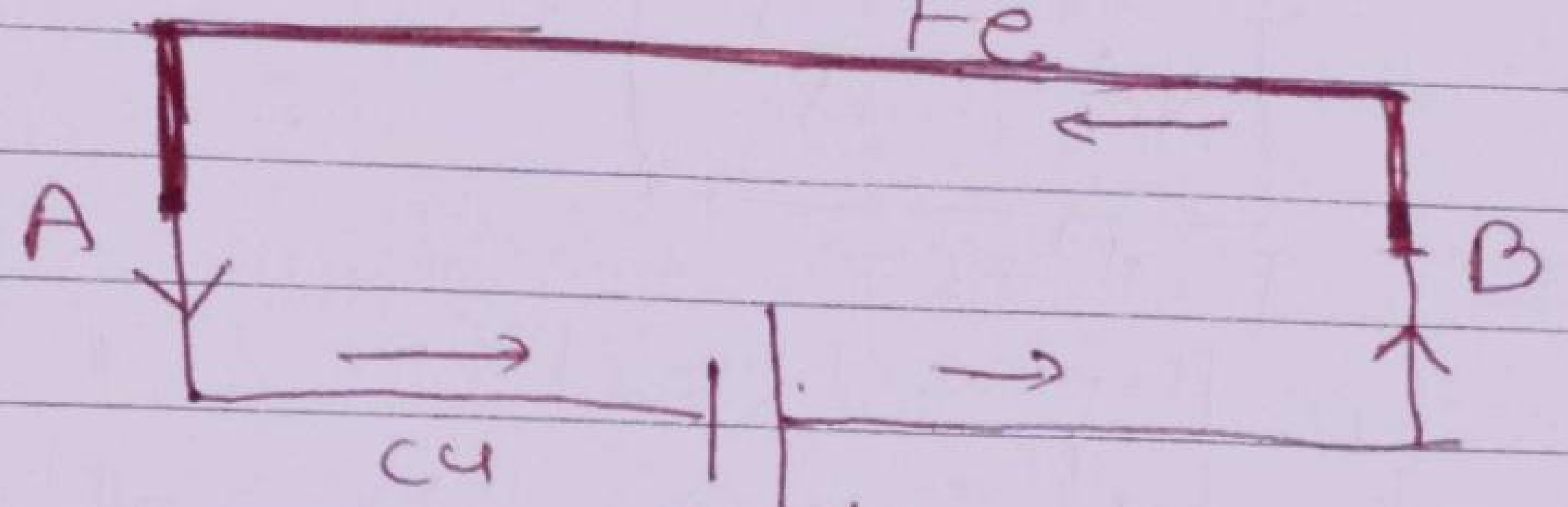
Peltier effect → An effect which is the converse of seebeck effect is called peltier effect. when an electric current is sent in a thermocouple cirucit by using an external seat of emf (cell) heat is either absorbed or evolved at the junction and consequently one junction is heated and the other is cooled is called peltier effect

or

The phenomenon of loss or gain of heat at the junction of two dissimilar metals when an electric current is passed across it is called peltier effect.

2017 Explanation →

Let us consider a Cu-Fe thermo-couple in which a battery is placed through ~~which~~ electric current passing.



Battery (emf)

The heat energy is absorbed at the junction B and this junction is cooled and heat energy is evolved at a junction A and this junction is heated. This evolution or absorption of heat energy at a junction of a thermo-couple is equal to πIt where I = current flowing though the thermo couple at time t.

$$Q = \pi I t$$

π = Peltier coefficient

If $I = 1$ $t = 1$ then

$$Q = \pi$$

The amount of heat energy absorbed or evolved due to peltier effect at a junction when a unit current flows for one sec. It is denoted by π.

If V be the contact potential difference at the junction, then the ~~heat~~ absorbed or evolved due

Joule's effect is VIt

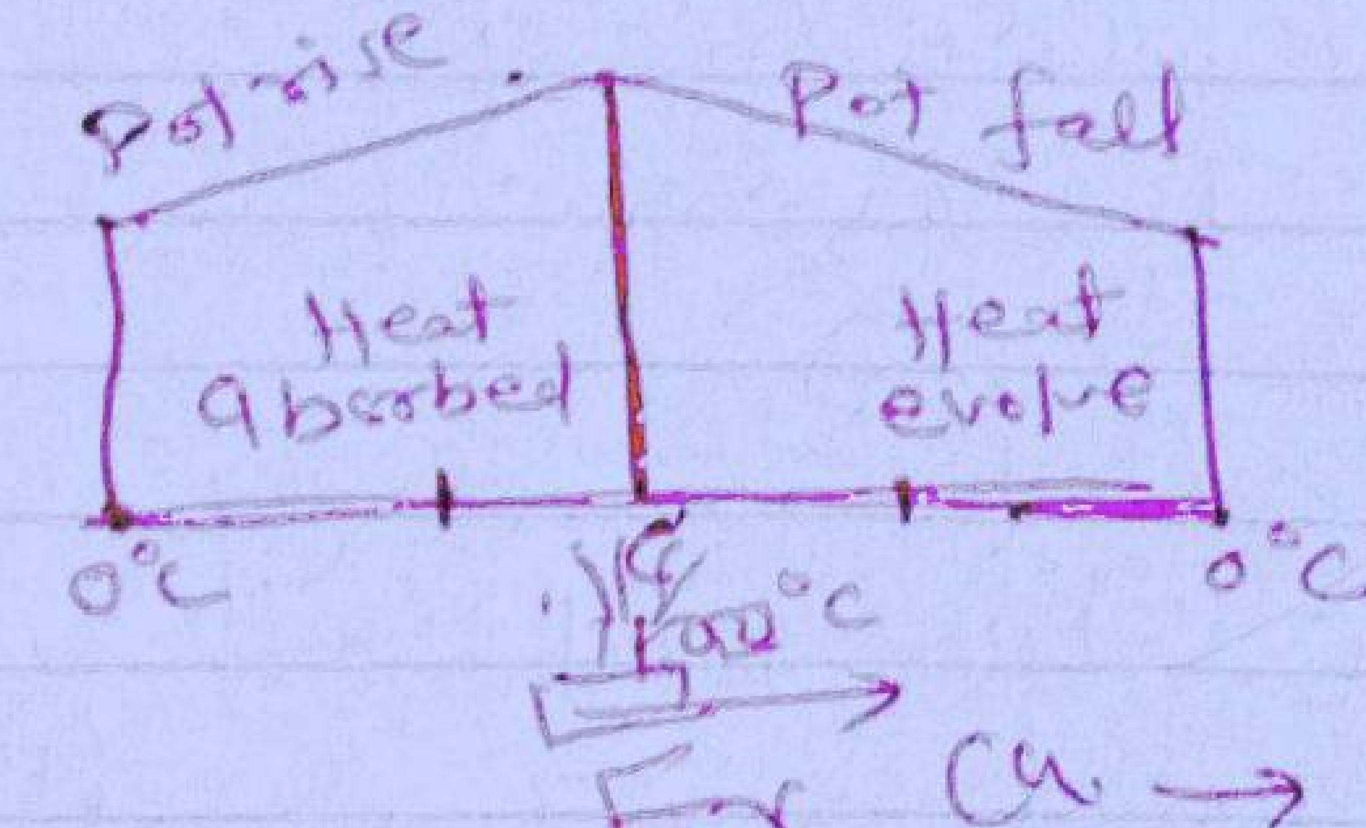
Sol $V I t = \pi I t$

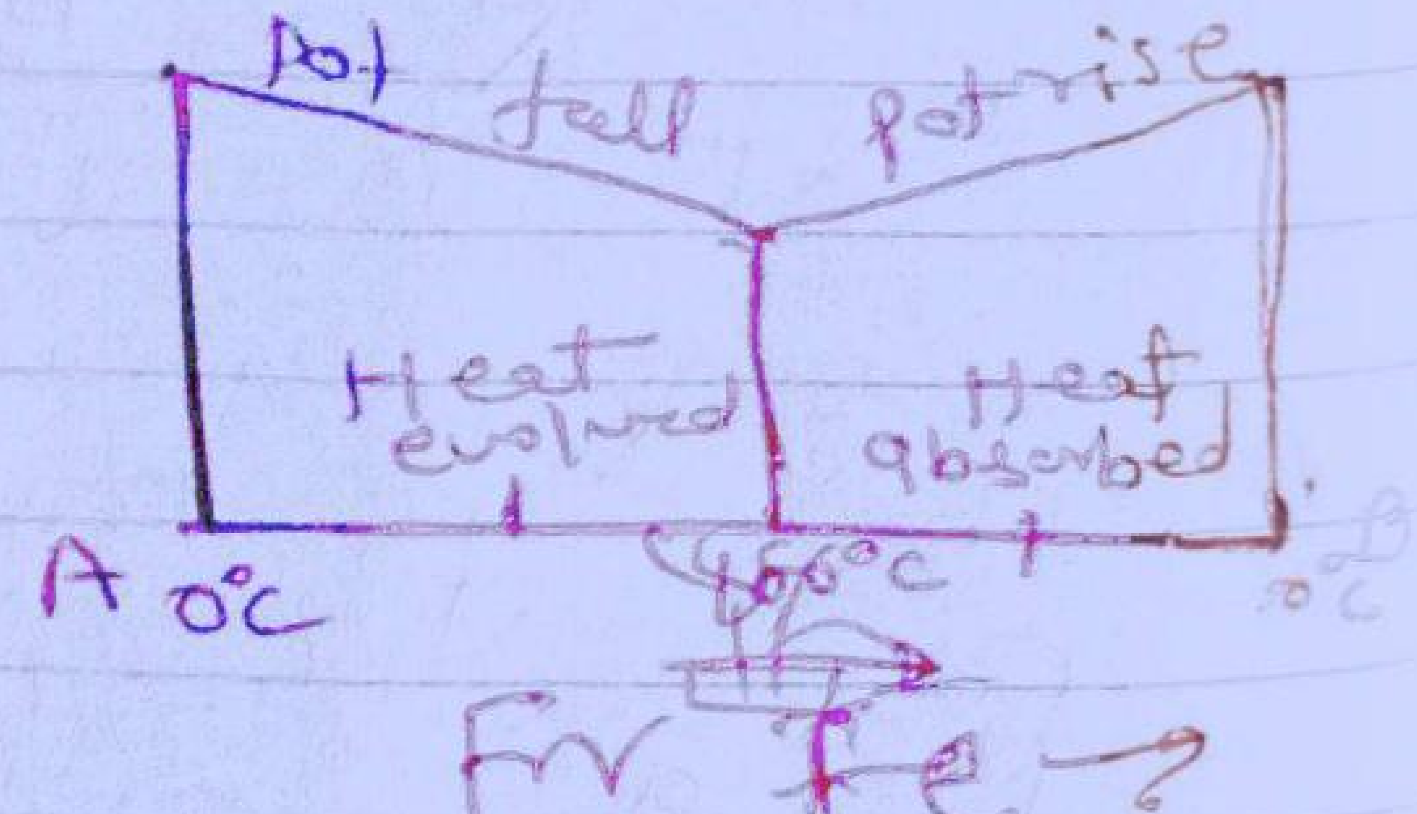
$$V = \pi$$

Hence peltier coefficient at a junction is numerically equal to the contact potential difference in volts.

The value of peltier coefficient is different for different pairs of metal.

Thomson effect → The absorption or evolution of heat energy if a current flows along a conductor when different parts of the conductor are at different temperature is known as Thomson effect.





The evolution or absorption of heat energy according to thomson effect is due to a difference of potential which exists at different points of an unequally heated conductor

In the case of substances having positive thomson effect. a point at a higher temp is at a higher potential than the point at a lower temp. Hence when current flows from a point at a lower temp to a point at a higher temperature, it flows from lower potential to a higher potential, Therefore, energy is required for a purpose which is absorbed from the material. The negative thomson effect in the case of substance at a point at a higher temperature is at a lower potential than the point at a lower temperature. Hence when current flows from a point at a lower temperature to a point at a higher temperature it flows from higher potential to lower potential. Heat energy is evolved when current flows from a point at a higher temp to a point at a lower temperature, it flows from lower potential to higher ~~potenti~~ potential. In such a case heat energy is absorbed

Thomson effect is not constant but varies with temperature. If a current I amp flows for t sec between two points of a conductor having a ~~temp~~ difference at 1°C

σ = thomson coeffi

Heat energy evolved or absorbed =

$$\sigma I t$$

V = Potential difference between the same two points in volt

Heat energy evolved or absorbed

$$= VIt$$

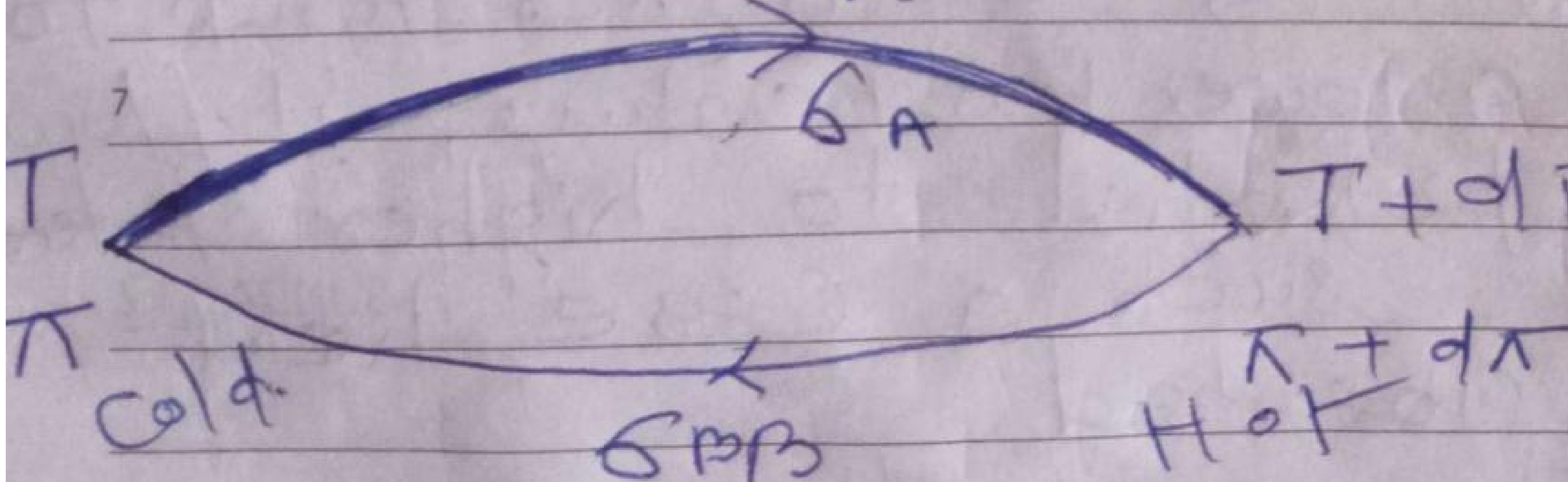
$$\therefore \sigma \cancel{I} \cancel{t} = V \cancel{I} \cancel{t}$$

$$\therefore \boxed{\sigma = V}$$

Thus thomson coefficient (σ) is numerically equal to the difference of potential per degree centigrade in volts.

Thomson coefficient is also known as the specific heat of electricity.

Expression for Peltier coefficient and Thomson coefficient →



let us consider a thermo-couple consisting of two metals A and B. ~~having~~

Cold junction at temp = T

Hot junction at temp = T + dT

π & $\pi + d\pi$ – peltier coefficient of metals

σ_A & σ_B = Thomson coefficient

let a current I flows for t sec in the direction A to B at the hot junction

Heat energy absorbed at temp $T+dT$ at the hot junction due to peltier effect $= (\pi + d\pi)(It)$

Heat energy evolved at a temp T at the cold junction due to Peltier effect $= \pi It$

Heat energy absorbed in the metal A due to Thomson effect $= \sigma_A \, dT \, It$

Heat energy evolved in the metal B due to Thomson effect $\sigma_B \, dT \, It$

$\therefore$ Net energy absorbed in the circuit =

$$(\pi + d\pi - \pi + \sigma_A \, dT - \sigma_B \, dT) It$$

$$= \{d\pi + (\sigma_A - \sigma_B) dT\} It$$

This energy used in setting up a potential diff dV in the couple-circuit which is equal to $dV It$.

$$dV It = \{d\pi + (\sigma_A - \sigma_B)\} It$$

$$dE = dV = d\pi + (\sigma_A - \sigma_B)\, dT$$

The amount of heat energy $(\pi + d\pi) I t$ is absorbed from the source at the hot junction at an absolute temperature $T + dT$ and an amount $(\sigma_A\, dT) I t$ Joules is absorbed in metal A at a mean absolute temp T,

An amount of heat energy $\pi I t$ Joules is given to the sink at the cold junction at an absolute temperature T and an amount $(\sigma_B\, dT) I t$ Joules is given out in the metal B at a mean absolute temperature T.

According to carnot's theorem

$$\frac{(\pi + d\pi) I t}{T + dT} + \frac{(\sigma_A\, dT) I t}{T} = \frac{\pi I t}{T} + \frac{(\sigma_B\, dT) I t}{T}$$

$$\frac{(\pi + d\pi) I t}{T + dT} - \frac{\pi I t}{T} + \frac{(\sigma_A - \sigma_B) I t\, dT}{T} = 0$$

$$\frac{\pi + d\pi}{T + dT} - \frac{\pi}{T} + \frac{(\sigma_A - \sigma_B)}{T} = 0$$

$$\frac{\pi T + d\pi T - \pi dT - \pi T - (\sigma_A - \sigma_B) dT\, T + (\sigma_A - \sigma_B) dT^2}{T(T + dT)}$$

or $T[d\pi + (\sigma_A - \sigma_B) dT] - \pi dT = 0$

$dE = d\pi + (\sigma_A - \sigma_B) dT$

So $T dE - \pi dT = 0$ power $p = \frac{dE}{dT}$

$\pi = T dE/dT = TP$

$$P = \pi/T$$

peltier coefficien is product of absolute temp and the thermoelectric power.

$\pi = TP = T dE/dT$

differentiating it w.r.to T

$\frac{d\pi}{dT} = T d^2E/dT^2 + dE/dT$

$dE/dT - \frac{d\pi}{dT} = -T d^2E/dT^2$

Now $dE = d\pi + (\sigma_A - \sigma_B) dT$

Dividing it dT in both side

$dE/dT = \frac{d\pi}{dT} + (\sigma_A - \sigma_B)$

So $\frac{d\pi}{dT} + (\sigma_A - \sigma_B) - \frac{d\pi}{dT} = -T d^2E/dT^2$

$$(\sigma_A - \sigma_B) = -T d^2E/dT^2$$

$dP/dT = 1/T (\sigma_A - \sigma_B)$