PHYSICS

BOOKS - DHANPAT RAI & CO PHYSICS (HINGLISH)

THERMOELECTRICITY

Example

1. A sensitive microphone cannot withstand currents greater than 0.05 A when connected

across a thermocouple of emf 8.5 m V , the current in a very low resistance ammeter placed in series in the circuit reads 34 mA. What is the resistance of the microphone?

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2. In a given thermocouple , the temperature of cold junction is 10° C , while the temperature of inversion is 510° C. What will be the neutral temperature?

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3. In a copper-iron thermocouple , the temperature of cold junction is 20° C and the neutral temperature is $280^{\circ}C$. Find the temperature of inversion.

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4. The cold junction of a thermocouple is kept at 10°C. Calculate the temperature at which thermo emf would be maximum. Given that thermo emf changes sign at 800K.

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5. Near room temperature , the thermo emf of a thermo couple is $40\mu V$ per degree. A galvanometer of 25Ω and capable of detecting current of the order of 4μ A is used. Calcualate the smallest temperature difference that can be detected with this galvanometer.

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6. The junctions of a $Ni - Cu$ thermocouple are maintained at $0^\circ C$ and $100^\circ C$. Calculate the Seebeck emf produced in the loop. $a_{Ni,Cu} = 16.3 \times 10^{-6} V^\circ C^{-1}$ and $b_{Ni,Cu} = -0.042 \times 10^{-6} V^\circ C^{-3}$

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7. The thermoelectric emf ε of a copper constantan thermocouple and the temperature θ of the hot junction (with cold

junction at 0°C) are found to satisfy approximately the following relation.

$\varepsilon = a\theta + b\theta^2$

where ε is in $\mu V, \theta$ in $.^{\circ} C$ and $\alpha = 41\mu V\,^{\circ}C^{-1}, b = 0.041\mu V\,^{\circ}C^{-2}$

What is the temperture of the hot junction when the thermoelectric emf is measured to be 5.5 mV?

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8. The emf ε of a Cu-Fe thermocouple varies with the temperature θ of the hot junction (cold junction at $0^{\circ}C$), as $\varepsilon(\mu V) = 14\theta - 0.02\theta^2$ Determine the neutral temperature.

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9. The thermo emf of a therocouple , one junction of which is kept at $0^{\circ}C$, is given by $\varepsilon = at + bt^2$ where a and b constants of the

thermocouple . Calculate the neutral temperature and peltier and Thomson coefficients.

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10. In a given thermocouple, the emfs at $250^\circ C$ and 50° C with respect to 0°C are $40\mu V$ and $5\mu V$ respectively. Find of emf generated when the junctions are maintained at the temperature at $250^\circ C$ and $50^\circ C$.

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11. A thermocouple is made of iron and constantan. Find the emf developed per$0^\circ C$ difference of temperature between the junctions, given that the thermo emf of iron and constantan against platinum are +1600 and $-3400\mu V$ per $100^\circ C$ difference of temperatures.

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12. The thermoelectric powers of iron and copper with respect to lead are +10.5 and $-3.5\mu V$ respectively at $100^\circ C$. Find the emf of Cu-Fe thermocouple when its junctions are maintained at 50° and 150° C.

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13. An emf of 1 V is developed when the temperature difference between the hot and cold junctions of a thermocouple is 100 K.

Assuming that the cold junction is heated by 20 K , determine the percentage change in the thermo emf.

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Problem

1. The thermoelectric pewers of Pt, Ni and Fe are -4 , -21 and $12\mu V$ per $0^{\circ}C$ respectively . What will be the magnitude of emf of Pt-Ni

and Ni-Fe thermocouples with junctions at $0^{\circ}C$ and $100^{\circ}C$?

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2. A thermocouple circuit consists of two thermal junctions and a low-resistance galvanometer , all in series. The galvanmeter has a resistance of 8Ω and the rest of the circuit has a resistance of 1.6Ω . The temperature develops an emf of 10 microvolt per degree Celsius difference of temperature

between the two junction. When one junction is kept is $0^{\circ}C$ and the other in a molten metal, the galvanmeter reads 8 millivolt. What is the temperature of the molten metal? Assume that the emf varies linearly with the temperature difference.

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Problems For Self Practice

1. In a thermocouple the temperature of cold junction is $20^{\circ}C$, while the temperature of inversion is 520° C. At what temperature is the thermo emf maximum?

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2. In a copper-iron thermocouple , the temperature of cold junction is 20° C and the neutral temperature is $280^{\circ}C$. Find the temperature of inversion.

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3. The emf of a thermocouple changes sign at 600 K. If the nertral temperature is $210^{\circ}C$, what is the temperature of cold junction?

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4. The themo emf of a copper-constantan thermocouple is $40\mu V.^{\circ}C^{-1}$ at room temperature. A galvanometer whose resistance is 80Ω and current sensitivity $1\mu A$

is used. Find the smallest temperature difference that the galvanometer can detect.

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5. Calculate the emf of silver-iron thermocouple with junction at 10° C and $80^{\circ}C$ given $\alpha = +13.31\mu V.^{\circ}C^{-1}$ and $\beta = -0.019\mu V.^{\circ}C^{-2}$.

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6. For a Cu-Fe thermocouple, nertral temperature is $270^{\circ}C$. If $\alpha = 15.86\mu V.^{\circ} V^{-1}$ then find the value of β

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7. The thermo emf of a copper-constantan thermocouple with one junction at $0^{\circ}C$ and the other at $t^{\circ}C$ is given by the relation

$$\varepsilon = at = \frac{1}{2}bt^2$$

where ε is in $\mu V, a = 41\mu V.^{\circ} C^{-2}$. If the

thermo emf developed is 5.5 mV, find the temperature of the hot junction.

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8. The emf in a lead-iron thermocouple , one junction of which is at $t^\circ C$ is given by

$\varepsilon = 178t - 2.4t^2 (\text{in } \mu V)$

where t is the temperature in $.^\circ C$ .Find the neutral temperature , Peltier coefficient and Thomson coefficient.

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9. For a certain thermocouple , $\varepsilon = \alpha\theta + \frac{1}{2}\beta\theta^{\circ}, where \theta.^{\circ} C$ is the temperature of the hot junction and $0^{\circ}C$ is the temperature of the cold junction . If $\alpha = 10\mu V.^{\circ} C^{-1}$ and $\beta = -\frac{1}{20}\mu V.^{\circ} C^{-2}$, find the neutral temperature and temperature of inversion.

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10. The thermo emf of a thermocouple is $40\mu VK^{-1}$ at room temperature. A galvanometer of resistance 100Ω capable of detecting current as law as $10\mu A$ is connected with one such thermocouple. Calculate the smallest temperature difference that can be detected by such a thermocouple.

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11. A thermocouple with one junction at ice-point , has emf given by the relation, $\varepsilon = a\theta + \frac{1}{2}b\theta^{\circ}$, where $\theta^{\circ}C$ is the temperature of the hot junction. If the emf has the value 4.05 mV and 9.85 mV at $\theta = 100^{\circ}$ C and $300^{\circ}C$ respectively . What is the emf at $\theta = 500^{\circ}C$?

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12. Find the emf developed per $.^{\circ} C$ temperature difference of an iron constantan thermocouple , given that thermo emf's of iron and constantan against platinum are $16 \mu V$ and $-34 \mu V \text{per}.^{\circ} C$ temperature.

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13. The thermoelectric powers of iron and nickel with respect to lead are +12 and $-20 \mu V$ respectivelty at $50^{\circ} C$. Find the emf of the an

iron-nickel thermocouple with junctions at $0^{\circ} C$ and 100° C.

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