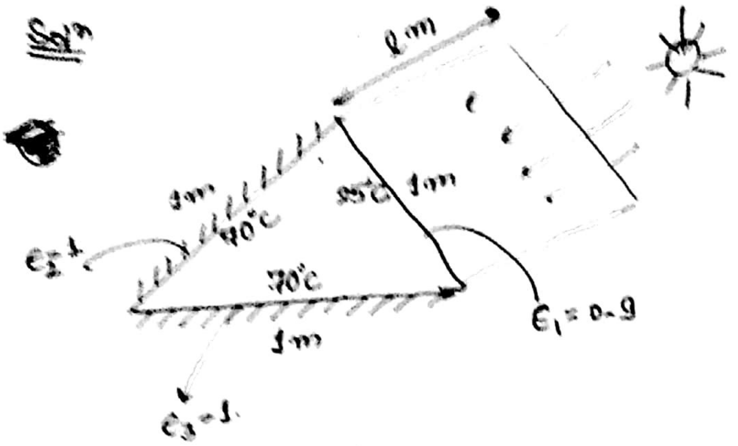
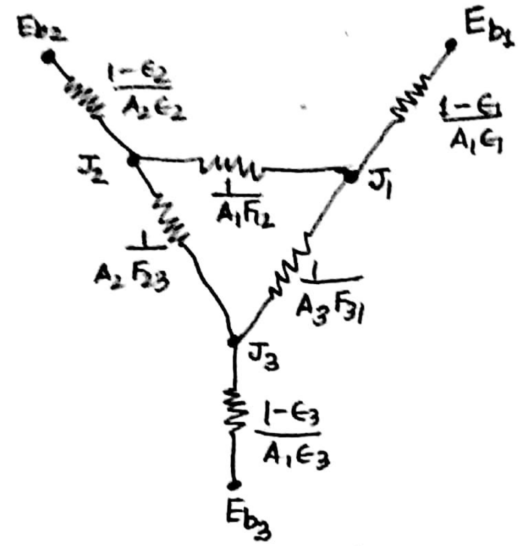
(5) A solar plate .... the absorber plates. :

Sol^n





Here, $\epsilon_1 = 0.9$

$\epsilon_2 = 1.0$

$\epsilon_3 = 1.0$

$A_1 = A_2 = A_3 = 1 \times l \ m^2$

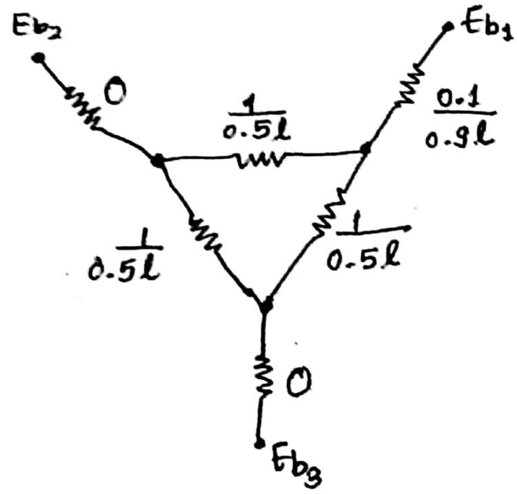
$= l m^2$

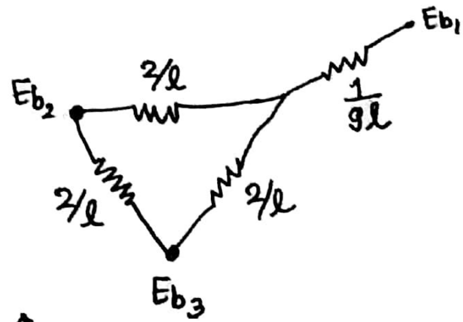
$F_{12} = F_{23} = F_{31} = 0.5$

$E_{b_1} = \sigma (298)^4 \ W/m^2$

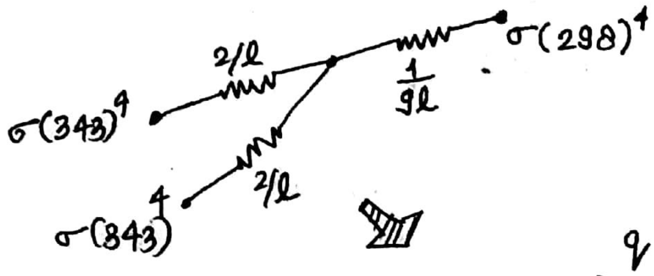
$E_{b_2} = E_{b_3} = \sigma (343)^4 \ W/m^2$

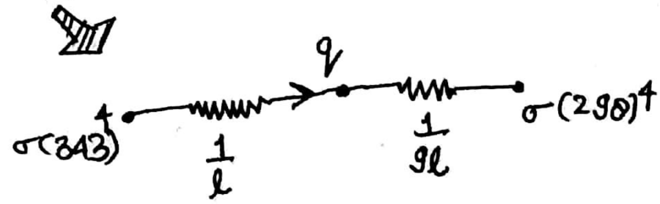
$\Rightarrow$





from symmetry





$$q = \frac{\sigma(343^4 - 298^4)}{\frac{1}{l} + \frac{1}{9l}}$$

$= 303.89 l$ W $\Rightarrow \boxed{\frac{q}{l} = 303.89 \ \frac{W}{m}}$

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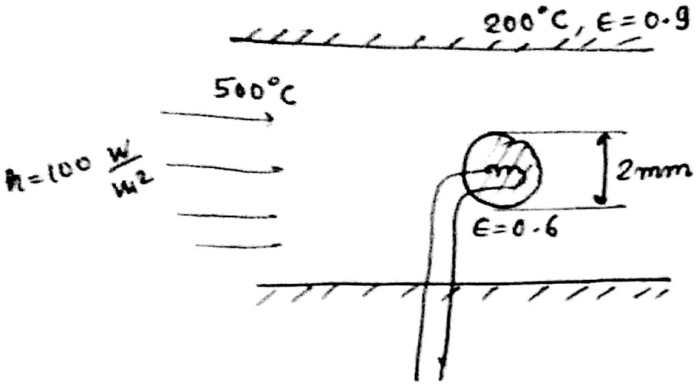
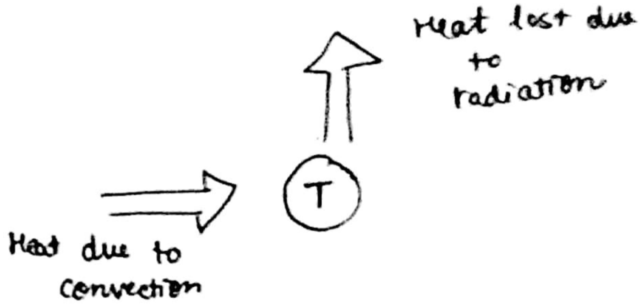
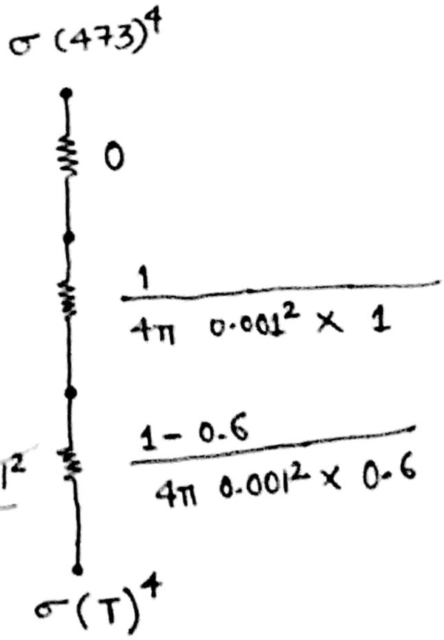
Thermo couple ------------------------------------ $h = 100\ W/m^2K$





Since A_1 is very large, $\frac{1-\epsilon_1}{A_1\epsilon_1} \rightarrow 0$

$\therefore$



$\therefore$ Heat due to convection = Heat loss due to radiation

$$\Rightarrow 100 \times \cancel{4\pi \times 0.001^2}\,(773 - T) = \frac{\sigma(T^4 - 473^4)\,\cancel{4\pi\,0.001^2}}{1 + \frac{0.4}{0.6}}$$

$\Rightarrow$ $\boxed{T = 705.66\ K}$

$\Rightarrow$ $\boxed{T = 432.66\ °C}$ → temperature indicated by the thermocouple.

KSHITIJ GAURAV VERMA

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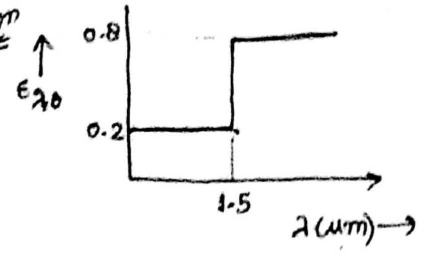
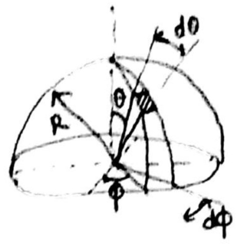
(2) The spectral, directional . . . . is 5800 K.

Sol^n



Since the material is diffuse

$\epsilon_{\lambda,\theta} = \epsilon_\lambda$

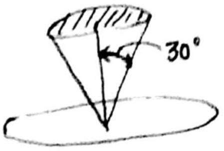


$dA = (R\,d\theta)(R\sin\theta\, d\phi)$

$= R^2 \sin\theta\, d\theta\, d\phi$

$d\Omega = \frac{dA}{R^2}$

$\boxed{d\Omega = \sin\theta\, d\theta\, d\phi}$



$$E = \int_{0.8um}^{2.5um} \int \int \epsilon_{\lambda,\theta}\, I_{b,\lambda}(\lambda,T) \cos\theta\, d\Omega\, d\lambda$$

$$= \int_{0.8um}^{2.5um} \int_0^{2\pi} \int_0^{\pi/6} \epsilon_{\lambda,\theta} \frac{E_{b,\lambda}}{\pi} \cos\theta \sin\theta\, d\theta\, d\phi\, d\lambda$$

$$= \frac{2\pi}{\pi} \int_{0.8}^{2.5} \int_0^{\pi/6} \epsilon_\lambda E_{b,\lambda} \cos\theta \sin\theta\, d\theta\, d\lambda$$

$$= 2 \int_0^{\pi/6} \cos\theta \sin\theta\, d\theta \int_{0.8}^{2.5} \epsilon_\lambda E_{b,\lambda}\, d\lambda$$

$$= 2 \times \frac{1}{8} \int_{0.8um}^{2.5um} \epsilon_\lambda E_{b,\lambda}\, d\lambda$$

$$= 0.25 \left(\frac{\int_{0.8um}^{1.5um} \epsilon_1 E_{b,\lambda} d\lambda + \int_{1.5um}^{2.5um} \epsilon_2 E_{b,\lambda} d\lambda}{\int_0^\infty E_{b,\lambda} d\lambda} \right) \int_0^\infty E_{b,\lambda} d\lambda$$

$$= 0.25 \left(\epsilon_1 [F_{0\to1.5} - F_{0\to0.8}] + \epsilon_2 [F_{0\to2.5} - F_{0\to1.5}] \right) E_b(T)$$

$$= 0.25 \left(0.2 (0.2732 - 0.0197) + 0.8 (0.6337 - 0.2732) \right) \sigma (2000)^4 \ \frac{W}{m^2}$$

$$= 76.90 \ \frac{kW}{m^2}$$

$$\frac{1}{2} \int_0^{\pi/6} 2\cos\theta \sin\theta\, d\theta$$

$$= \frac{1}{2} \int_0^{\pi/6} \sin 2\theta\, d\theta$$

$$= \frac{1}{2} \left(-\frac{\cos 2\theta}{2} \right)_0^{\pi/6}$$

$$= -\frac{1}{4} \left(\cos\frac{\pi}{3} - 1 \right)$$

$$= -\frac{1}{4} \left(\frac{1}{2} - 1 \right)$$

$$= \frac{1}{8}$$

we know $\epsilon_{\lambda,\theta} = \alpha_{\lambda,\theta}$ since diffuse surface

$$\alpha(T) = \int_0^\infty \alpha_\lambda(\lambda) E_{\lambda,b}(\lambda,T)\, d\lambda / E_b(T) \quad \because \alpha_{\lambda,\theta} = \alpha_\lambda$$

$$= \int_0^{1.5} \alpha_1 E_{\lambda,b}(\lambda, 5800)\, d\lambda / E_b + \int_{1.5}^\infty \alpha_2 E_{\lambda,b}(\lambda, 5800)\, d\lambda / E_b$$

$$= \alpha_1 F_{0\to1.5} + \alpha_2 (1 - F_{0\to1.5})$$

$\lambda T \to 1.5 \times 5800 = 8700$ umK

$F_{0\to1.5} = 0.8684396$

$$= 0.2 \times 0.8684396 + 0.8 (1 - 0.8684396)$$

$$= 0.279$$

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