

HW 11

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CHEM 3453

1) $D = 0.2 \text{ m} \rightarrow A = \pi r^2 = 0.0314 \text{ m}^2$

$$T_s = 250^\circ\text{C} = 523 \text{ K}$$

$$T_{\text{air}} = 20^\circ\text{C} = 293 \text{ K}$$

$$q = A \epsilon \sigma (T_s^4 - T_{\text{air}}^4) = 0.0314 \cdot 1 \cdot 5.67 \times 10^{-8} (523^4 - 293^4)$$

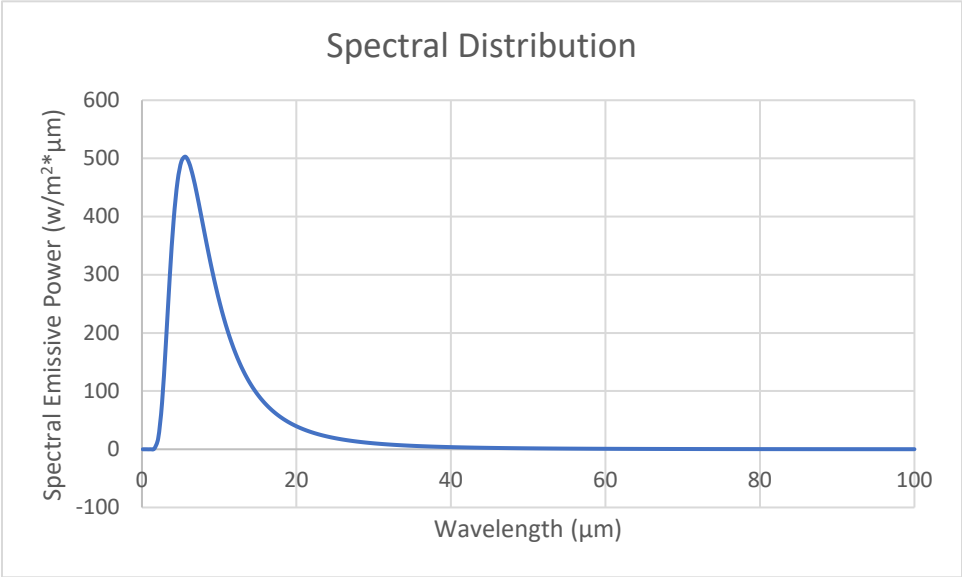
$$\boxed{= 120. \text{ W}}$$

}

I f $\eta = 0.90 \rightarrow P_{\text{elec}} = \frac{q}{\eta} = \frac{120}{0.9} = 133 \text{ W}$

$$\text{Max } E: \boxed{\lambda \approx 5.6 \text{ } \mu\text{m}}$$

$$E = \frac{2898}{T_s}$$



$$2) E_b = \epsilon \sigma (T_s)^4 = 0.6 \cdot 5.67 \times 10^{-8} \cdot 320^4$$

$$= \underline{357}$$

$$F(\lambda_1 - \lambda_2) = \frac{\int_{\lambda_1}^{\lambda_2} E_{\lambda_2,b} d\lambda - \int_{\lambda_1}^{\lambda_2} E_{\lambda_1,b} d\lambda}{\sigma T^4}$$

$$E_{\lambda_2} = \frac{C_1}{15^5 \left(\exp \frac{C_2}{15 \cdot 320} - 1 \right)} = 25.9 \quad C_1 = 3.742 \times 10^8$$

$$C_2 = 1.439 \times 10^{-4}$$

$$E_{\lambda_1} = \frac{C_1}{3.75^5 \left(\exp \frac{C_2}{3.75 \cdot 320} - 1 \right)} = 3.13$$

$$\therefore F(\lambda_1 - \lambda_2) = \frac{(25.9 \cdot 15) - (3.13 \cdot 3.75)}{\sigma \cdot 320^4} = 0.633$$

$$E = 0.633 \cdot 357 = \boxed{226 \frac{W}{m^2}}$$

$$3) T = 3033 \text{ K}$$

Band 1

$$\lambda_1 T = 0.2 \cdot 3033 = 606.6 \rightarrow F_{0 \rightarrow \lambda} \approx 0$$

$$\lambda_2 T = 1 \cdot 3033 \rightarrow F_{0 \rightarrow 1} \approx 0.273$$

For band 1 $F = 0.273$

$$q_1'' = \epsilon \cdot (F_{0 \rightarrow 1} - F_{0 \rightarrow 0.2}) \cdot \sigma \cdot T^4 = 1165947 \frac{\text{W}}{\text{m}^2}$$

Band 2

$$\lambda_1 T = 4 \cdot 3033 = 12132 \rightarrow F_{0 \rightarrow 4} \approx 0.945$$

$$\lambda_2 T = 10 \cdot 3033 = 30330 \rightarrow F_{0 \rightarrow 10} \approx 0.995$$

For band 2 $F = 0.050$

$$q_2'' = \epsilon (F_{0 \rightarrow 10} - F_{0 \rightarrow 4}) \cdot \sigma T^4 = 95962.8 \frac{\text{W}}{\text{m}^2}$$

$$q_{\text{tot}}'' = q_1'' + q_2'' = 1.26 \times 10^6 \frac{\text{W}}{\text{m}^2} = \frac{3.41 \text{ Btu/hr}}{1 \text{ W}} \cdot \frac{1 \text{ W}}{0.7639 \text{ ft}^2}$$

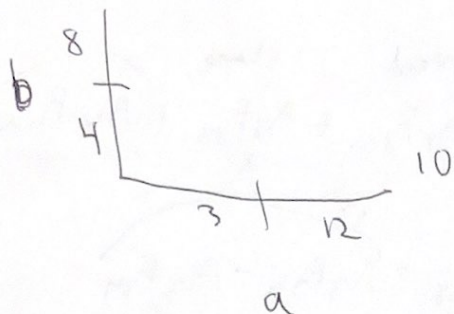
Ans.

$= 4.00 \times 10^5 \frac{\text{Btu}}{\text{hr ft}^2}$
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4)



$$\underbrace{A_b F_{ba}}_{\text{have}} = \underbrace{A_8 F_{8-12}}_{\text{need}} + \underbrace{A_8 F_{83}}_{\text{need}} + \underbrace{A_4 F_{4a}}_{\text{have}}$$

$$A_8 F_{83} = A_3 F_{38} = A_3 F_{3b} - A_3 F_{34}$$

$$\therefore A_b F_{ba} = A_8 F_{8-12} + A_3 F_{3b} - A_3 F_{34} + A_4 F_{4a}$$

$$\rightarrow F_{8-12} = \frac{A_b F_{ba} - A_3 F_{3b} + A_3 F_{34} - A_4 F_{4a}}{A_8}$$

$$F_{ba} \approx 0.2$$

$$A_b = 120$$

$$F_{3b} \approx 0.35$$

$$A_3 = 30$$

$$F_{34} \approx 0.3$$

$$A_4 = 40$$

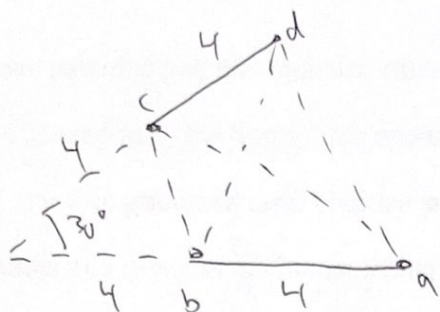
$$F_{4a} \approx 0.33$$

$$A_8 = 80$$

$$\therefore F_{8-12} = 0.116$$


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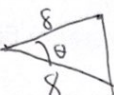
5)




Law of cosines

$$c = \sqrt{a^2 + b^2 - 2ab \cos(\theta)}$$

\overline{bc} :  $\rightarrow \overline{bc} = \sqrt{4^2 + 4^2 - 2 \cdot 4 \cdot 4 \cos(30^\circ)} \approx 2.07$

\overline{ad} :  $\rightarrow \overline{ad} = \sqrt{8^2 + 8^2 - 2 \cdot 8 \cdot 8 \cos(30^\circ)} \approx 4.14$

$\overline{ac} = \overline{bd}$:  $\overline{ac} = \sqrt{4^2 + 8^2 - 2 \cdot 4 \cdot 8 \cdot \cos(30^\circ)} \approx 4.96$

$$F_{12} = \frac{1}{2\mu_0} (ac + bd - ad - bc)$$

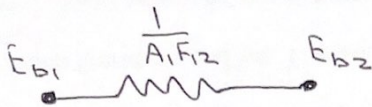
$$= \frac{1}{8} (4.96 + 4.96 - 4.14 - 2.07)$$

$$\approx 0.463$$

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6.)



$$q = \frac{E_{b1} - E_{b2}}{1/A_1 F_{12}}$$

$$L = 10 \text{ ft} = 3.048 \text{ m}$$

$$F_{12} \approx 0.2$$

$$T_1 = 3600^\circ \text{R} = 2000 \text{ K}$$

$$T_2 = 2000^\circ \text{R} = 1111 \text{ K}$$

$$q = \frac{\sigma (T_1^4 - T_2^4)}{1/(3.041^2 \cdot 0.2)} = 1925060 \text{ W} \cdot 3.41 \frac{\text{Btu/hr}}{\text{W}}$$

$$= 5.20 \times 10^6 \frac{\text{Btu}}{\text{hr}}$$

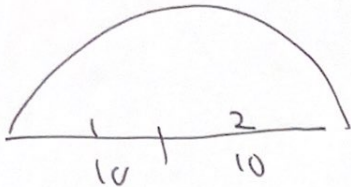
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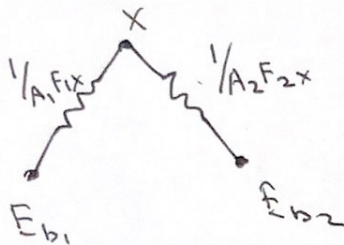
7.)



$$T_1 = 2100^\circ\text{F} = 1422\text{K}$$

$$T_2 = 1000^\circ\text{F} = 810.9\text{K}$$

$$A_1 = 10.30 = 300\text{ft}^2 = 27.87\text{m}^2 = A_2$$



$$F_{1X} = F_{2X} = 1$$

$$\therefore q = \frac{\sigma(T_1^4 - T_2^4)}{\frac{1}{A_1 F_{1X}} + \frac{1}{A_2 F_{2X}}}$$

$$= \frac{5.67 \times 10^{-8} (1422^4 - 810.9^4)}{\frac{1}{27.87} + \frac{1}{27.87}} = 2889101 \text{ W} \cdot 3.41$$

$$= 9.85 \times 10^6 \frac{\text{Btu}}{\text{hr}}$$