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A) Recall

$E = \pi L$

where L = Brightness

Considering reflection factor (r.e) of 85% → 0.85

$r.e \cdot E = \pi L$

$L = \frac{E}{\pi} \times$ reflection factor

i) when $E = 44,000$ lux

$L = \frac{44000}{\pi} \times 0.85$

$L = 11904.7897 \ cd/m^2$

$L = 1.1905 \times 10^4 \ cd/m^2$

ii) when $E = 0.22$ lux

$L = \frac{0.22}{\pi} \times 0.85 = 0.0595 \ cd/m^2$

$L = 5.95 \times 10^{-2} \ cd/m^2$

B) $I = 120$ cp

Luminance = $\frac{\text{flux emitted by globe}}{\text{Area}}$

flux emitted by source

$\phi = I \times \omega = 120 \times 4\pi$

$= 480\pi$ lumen

flux absorbed by globe

$= 480\pi \times 0.3$

$= 144\pi$ lumen

flux emitted by globe = flux Emitted by source
- flux absorbed by globe

$= (480\pi - 144\pi)$ lumen

$= 336\pi$ lumen

i) Luminance $= \frac{336\pi}{\pi \times 0.2^2}$ $\left(\frac{\text{flux emitted by globe}}{\text{Area}}\right)$

$= 6942.1487$ lm/m^2

ii) Candle power, $C_p = \frac{\text{lumen}}{\omega}$

$= \frac{336\pi}{4\pi} = 84$ cd

c) Area $= 75$ cm^2

$t = 2$cm

$\Delta\theta = (80 - 30)^\circ C = 50^\circ C$

time taken $= 8$ mins

ε_r 6.5

$c = 0.255$ cal/g°C

$\rho = 0.55$ g/cm^3

$\cos\phi = 0.04$, $f = 20$mHz

15% wastage of heat input

heat required $= mc\Delta\theta$

$m =$ Density $\times$ volume

$= 0.55 \times 75 \times 2$

$= 82.5$ g

$C = \frac{\varepsilon_0 \varepsilon_r A}{t} = \frac{8.85 \times 10^{-12} \times 6.5 \times 75 \times 10^{-4}}{2 \times 10^{-2}}$

$C = 21.5719 \times 10^{-12}\ F$

$\omega = 2\pi f$

$= 2\pi \times 20 \times 10^{6}$

$= 1.2566 \times 10^{8}\ rad/s$

$\cos\phi = 0.04$

$\Rightarrow \phi = 87.7076^{\circ}$

$\delta = 90 - \phi$

$= 90 - 87.7076$

$= 2.2924^{\circ}$

Heat required $= mc\Delta\theta$

$= 82.5 \times 0.25 \times 50$

$= 1051.875\ Cal$

with 15% wasted, 85% useful

Total heat required $= 1051.875 \times 0.85$

$= 894.0937\ Cal$

Power input $= 894.0937 \times 4.186$

(recall $1\ cal = 4.186\ J$)

Energy input $= 3742.6764\ J$

$\text{Power} = \frac{\text{Energy}}{\text{time}} = \frac{3742.6764}{8 \times 60} = 7.7972\ W$

$P_d = V^2 \omega C \tan\delta$

$V^2 = \frac{P_d}{\omega C \tan\delta} = \frac{7.7972}{1.2566 \times 10^{8} \times 21.5719 \times 10^{-12} \times \tan 2.3}$

$V^2 = 71616.75701$

$\Rightarrow V = 267.6131\ V$

$P = IV\cos\phi \Rightarrow I = \frac{7.7972}{267.6131 \times 0.04} = 0.7284\ A$