1. What is the total power radiated per unit area by a tungsten filament at $T = 3000 \, \text{K}$? Show your work.

Stefan-Boltzmann's law: $P = \sigma \cdot T^4 = 5.67 \times 10^{-8} \, \frac{W}{m^2 \cdot \text{K}^4} \times (3000)^4 = 4.6 \times 10^6 \, \frac{W}{m^2} = 4.6 \, \frac{MW}{m^2}$

2. If the tungsten filament of a light bulb is rated 75 W, what is the surface area of the filament? Show your calculations. Assume 10% of luminous efficacy of the bulb.

To achieve 10% of luminous efficacy a bulb's filament must be at $T \approx 2500 \, ^\circ \text{C} = 2773 \, \text{K}$ (at least!). Thus, total power per unit area $P = \sigma \cdot T^4 = 5.67 \times 10^{-8} \, \frac{W}{m^2 \cdot \text{K}^4} \times (2773 \, \text{K})^4 = 3.35 \times 10^6 \, \frac{W}{m^2}$

Area $A = \frac{75 \, \text{W}}{P} = 22.4 \times 10^{-6} \, \text{m}^2$

$A = 0.22 \, \text{cm}^2$

3. Rather than having two 60 Watt bulbs in parallel for lighting in a room, a lamp is rewired so that the two 60 Watt bulbs are in series. Answer the following questions (show your work).

A) Does the electric bill go up, down or stay the same and why? $\boxed{\text{Go down by a factor } \frac{30}{120} = \frac{1}{4}}$

B) Assume that incandescent bulbs give off 20 lumens/Watt (this is incorrect since higher power bulbs give off more lumens/Watt). How much light is given off by the two 60 Watt bulbs in parallel and in series? $P_{\text{light}} = 2 \times 20 \, \frac{\text{lumen}}{\text{W}} \times 60 \, \text{W} = 2400 \, \text{lumens (parallel)}$ or $2 \times 20 \times 15 = 600 \, \text{lumens (series)}$

C) Was this a good idea in terms of obtaining better lighting in the room? $\boxed{\text{Bad idea}}$

For parallel: $P_{\text{net}} = 2 \times 60 \, \text{W} = 120 \, \text{W}$

For in-series: Current through each is $I = \frac{120 \, \text{V}}{2 \times 240 \, \Omega} = 0.25 \, \text{A}$

$I = \frac{60 \, \text{W}}{120 \, \text{V}} = 0.5 \, \text{A}$, $R = \frac{V}{I} = \frac{120 \, \text{V}}{0.25 \, \text{A}} = 480 \, \Omega$, $P_{\text{net}} = 120 \, \text{V} \times 0.25 \, \text{A} = 30 \, \text{W}$

4. An astronomer has measured that the peak wavelength of the emission of a distant hot planet is $\lambda_{\text{max}} = 2.90 \, \mu\text{m}$. Estimate the radiation power (cumulative of all wavelengths) emitted by this planet per unit area of its surface. Assume that the absolute black-body radiation model applies.

Wien's law: $\lambda_{\text{max}} = 2.9 \times 10^{-3} \times \frac{1}{T}$, where $\lambda_{\text{max}}$ is in meters, $T$ is in Kelvin.

$\Rightarrow T = \frac{2.9 \times 10^{-3} \, \text{[m/K]}}{2.9 \times 10^{-6} \, \text{[m]}} = 10^3 \, \text{[K]}$ ($\lambda_{\text{max}} = 2.9 \, \mu\text{m} = 2.9 \times 10^{-6} \, \text{m}$)

Stefan-Boltzmann's law: $P = \sigma \cdot T^4 = 5.67 \times 10^{-8} \, \frac{W}{m^2 \cdot \text{K}^4} \times (10^3 \, \text{K})^4$

$P = 5.67 \times 10^4 \, \frac{W}{m^2}$