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Blackbody radiation and the Stefan-Boltzmann law

Q1: The heating wires of a 1 kW electric heater are "red hot" at a temperature of 900 °C. Assuming that 100 percent of the heat output is due to radiation and that the wires act as blackbody radiators, what is the effective area of the radiating surface? (Assume a room temperature of 20 °C.)

Q2: A copper ball 2 cm in radius is heated in a furnace to 400 °C. If its emissivity is 0.3, at what rate does it radiate energy?

Q3: The sun radiates energy at the rate of 6.5×10^7 W/m^2 from its surface. Assuming that the sun radiates as a blackbody (which is approximately true), find its surface temperature. (Note that the emissivity of a blackbody $e = 1$, and that the rate of energy radiation is the power radiated per unit area.)

Q4: In the operation of a *thermograph*, the radiation from each small area of a person's skin is measured and shown by different shades of gray or by different colors in a *thermogram.* Because the skin over a tumor is warmer than elsewhere, thermograms are used in screening for various cancers. What is the percentage difference between the radiation rates from skin at 34 and 35 °C?

Q5: Calculate the *net loss* in radiated energy for a naked person in a room at 20 °C, assuming the person to be a blackbody with a surface area of 1.4 m^2 and a surface temperature of 33 °C = 304 K. (The surface temperature of the human body is slightly less than the internal temperature, about 37 °C, because of the thermal resistance of the skin.)

Q6: Find λ_{max} for blackbody radiation at *(a)* $T = 3$ K, *(b)* $T = 300$ K and *(c)* $T = 3000$ K. (Note: $c = f_{max}\lambda_{max}$)

Q7: Find the temperature of a blackbody if its spectrum has its peak at *(a)* $\lambda_{max} = 700$ nm, *(b)* $\lambda_{max} = 3$ cm (microwave region) and *(c)* $\lambda_{max} = 3$ m (FM radio waves). (Note: $c = f_{max}\lambda_{max}$)

Q8: The fact that all bodies radiate due to their temperature enables non-invasive temperature measurement over a range of temperatures. This radiation can only be modelled by making the assumption that energy is quantised, i.e. comes in discrete parcels, called "quanta". Taking the first derivative of the blackbody equation, we find that

$$3(1 - e^{-x}) = x$$

where $x = hf_{max}/(kT)$. The solution to this equation is $x \approx 2.82$. *(a)* At what frequency is the maximum intensity of blackbody radiation for $T = 300$ K? *(b)* What wavelength does this represent?

Q9: From a measured maximum intensity wavelength of $\lambda_{max} = 589$ nm, *(a)* what is the temperature? *(b)* What is the temperature for $\lambda_{max} = 16.4\ \mu$m? *(c)* What is the likely source in both cases?

Q10: Why have most terrestrial creatures evolved electromagnetic sensors (i.e. eyes) that function in the visible part of the electromagnetic spectrum?