39.3 • An electron has a de Broglie wavelength of 2.80×10^{-10} m. Determine (a) the magnitude of its momentum and (b) its kinetic energy (in joules and in electron volts). $1.6\times10^{-19}\,J = 1\,eV$

$$p = \frac{h}{\lambda} = \frac{6.6\times10^{-34}\,Js}{2.8\times10^{-10}\,m} \quad \ldots \; kg\,m/c$$

$$p = \frac{h}{\lambda} = \left(\frac{hc}{\lambda}\right)\frac{1}{c} = \frac{1.24\,KeV\,nm}{0.28\,nm\;c} = 5\left(\frac{KeV}{c}\right) = 5\times10^{3}\left(\frac{eV}{c}\right)$$

$$K = \frac{1}{2}mv^2 = \frac{p^2}{2m} = \frac{(pc)^2}{2mc^2} = \frac{25\times10^{6}\,eV^2}{2\times0.511\times10^{6}\,eV} \approx 25\,eV$$

$$m_ec^2 = 0.511\,MeV$$

39.4 •• Wavelength of an Alpha Particle. An alpha particle ($m = 6.64 \times 10^{-27}$ kg) emitted in the radioactive decay of uranium-238 has an energy of 4.20 MeV. What is its de Broglie wavelength?

$$K_\alpha = \frac{1}{2} m_\alpha v^2 = \frac{p^2}{2m} = 4.20 \times 10^6 \text{ eV}$$

$$m_\alpha c^2 \simeq 4 \text{ GeV}$$

$$p = \sqrt{2 m K_\alpha}$$

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2 m_\alpha (K_\alpha)}} = \frac{6.6 \times 10^{-34} \text{ Js}}{\sqrt{2 \times 6.64 \times 10^{-27} \text{ kg} \left(4.2 \times 10^6 \text{ eV} \times \frac{1.6 \times 10^{-19} \text{ J}}{1 \text{ eV}}\right)}}$$

39.41 •• A 100-W incandescent light bulb has a cylindrical tungsten filament 30.0 cm long, 0.40 mm in diameter, and with an ~~emissivity of 0.26~~. (a) What is the temperature of the filament? (b) For what wavelength does the spectral emittance of the bulb peak? (c) Incandescent light bulbs are not very efficient sources of visible light. Explain why this is so.

AREA $\approx (2\pi R)L$

$P = 100\,W = (\text{INTENSITY}) \times (\text{AREA})$ & $R = \frac{1}{2} 0.4\,mm$; $L = 0.3\,m$

$= (\sigma T^4) \times (2\pi R L) \rightarrow$ SOLVE T

$\lambda_{MAX} = \frac{2.9 \times 10^{-4} \ldots}{T}$

39.43 • Radiation has been detected from space that is characteristic of an ideal radiator at $T = 2.728$ K. (This radiation is a relic of the Big Bang at the beginning of the universe.) For this temperature, at what wavelength does the Planck distribution peak? In what part of the electromagnetic spectrum is this wavelength?

WIEN. DISPLACEMENT LAW

$\lambda_m T = 2.9 \times 10^{-3}$ mK ; $\lambda_m = \frac{2.9 \times 10^{-3} \text{ mK}}{2.72}$

$\lambda_m \simeq 10^{-3}$ m $\simeq 1$ mm MICROWAVE

39.61 •• **The Red Supergiant Betelgeuse.** The star Betelgeuse has a surface temperature of 3000 K and is 600 times the diameter of our sun. (If our sun were that large, we would be inside it!) Assume that it radiates like an ideal blackbody. (a) If Betelgeuse were to radiate all of its energy at the peak-intensity wavelength, how many photons per second would it radiate? (b) Find the ratio of the power radiated by Betelgeuse to the power radiated by our sun (at 5800 K).

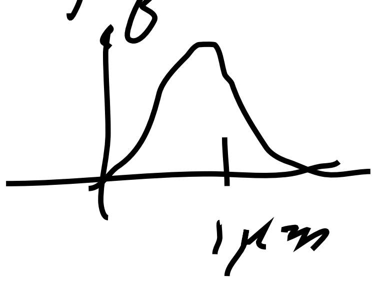
$P_{SUN} = \sigma T_{SUN}^4 (4\pi R_{SUN}^2)$

$P_B = (\sigma T_B^4)(4\pi R_B^2)$

$\lambda_{mB} = \frac{2.4\times10^{-3}\ mK}{3\times10^{3}\ mK} = 10^{-6}\ m \simeq 1\ \mu m \rightarrow IR$

$\frac{P_B}{P_S} = \left(\frac{T_B}{T_S}\right)^4 \left(\frac{R_B}{R_S}\right)^2 \approx \left(\frac{1}{2}\right)^4 (600)^2$

$= \frac{3.6\times10^5}{16} \approx 2\times10^5$



39.63 • What must be the temperature of an ideal blackbody so that photons of its radiated light having the peak-intensity wavelength can excite the electron in the Bohr-model hydrogen atom from the ground state to the third excited state?

$$E_\gamma = \frac{hc}{\lambda} = E_3 - E_1 = -13.6\,\text{eV}\left(\frac{1}{9} - 1\right) = 13.6\,\frac{8}{9}\,\text{eV}$$

$$\lambda = \frac{1240\,\text{eV nm}}{13.6 \times \frac{8}{9}} = 103\,\text{nm} \quad \text{UV} \checkmark = 1.03 \times 10^{-7}\,\text{m}$$

$$\lambda_m T = 2.9 \times 10^{-3}\,\text{mK} \qquad T = \frac{2.9 \times 10^{-3}\,\text{mK}}{1.03 \times 10^{-7}\,\text{m}} = 2.8 \times 10^{4}\,\text{K}$$

$$= 28{,}000\,\text{K}$$