3-2 3rd ed

~~2-2~~

According to Wien's displacement "law",

$$\lambda_{max} T = 0.2898 \times 10^{-2}\ m \cdot K$$

We're given $T = 35^{\circ}C \equiv 308K$.
(+273)

Solve for λ_{max}

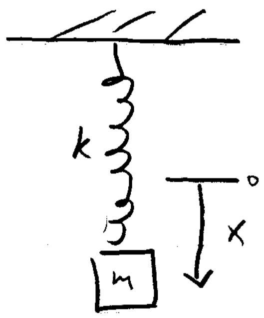
$$\lambda_{max} = \frac{0.2898 \times 10^{-2}\ mK}{308K}$$

$$\lambda_{max} = 9.41 \times 10^{-6}\ m$$

This wavelength is in the middle of the IR band.

3-3 3rd ed

~~2-3~~



$k = 25\ N/m$

$m = 2.0\ kg$

$x_0 = 0.40\ m$

$v_0 = 0\ m/sec$

a) For a simple harmonic oscillator

$$E = K + P$$

$$E = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$$

initially $v = 0$ and $x = x_0$, so

$$E = \frac{1}{2}kx_0^2 = 2 \text{ Joules}$$

The oscillation frequency is $f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$

$$f = \frac{1}{2\pi}\sqrt{\frac{25\ N/m}{2.0\ kg}} = 0.563\ Hz$$

b) The energy quantum is $\Delta E = hf$.

$$n = \frac{E}{hf} = \frac{2 \text{ Joules}}{6.626\times10^{-34}\ J\cdot sec\ (0.563\ Hz)}$$

$$n = 5.36\times10^{33}$$

c) $\Delta E = hf = 6.626\times10^{-34}\ J\cdot sec\ \ 0.563\ Hz = 3.73\times10^{-34}$ Joules

3.4 3rd ed

~~24~~

Stefan's "Law": $\frac{P}{A} = \sigma T^4$,

where P is the emitted power and A is the total surface area of the filament, and σ = Stefan's constant

a) For T = 3000K,

$$\frac{P}{A} = 5.7 \times 10^{-8} \frac{W}{m^2K^4} (3000K)^4$$

$$= 4.62 \times 10^6 \frac{W}{m^2}$$

b) If P = 75W, solve for A

$$A = \frac{P}{4.62 \times 10^6 \frac{W}{m^2}}$$

$$= \frac{75\,W}{4.62 \times 10^6 \,W/m^2}$$

$$= 1.62 \times 10^{-5}\ m^2$$

The total surface area of the filament is $1.62 \times 10^{-5}\ m^2$.

3-8 3rd ed

~~2.7~~ The energy of a photon is $E = hf$.

a) $f = 5 \times 10^{14}$ Hz
$E = 4.136 \times 10^{-15}$ eV sec $\cdot 5 \times 10^{14}$ Hz $= 2.07$ eV.
[3.32×10^{-19} J]

b) $f = 10$ GHz
$E = 4.136 \times 10^{-15}$ eV·sec $\cdot 10 \times 10^{9}$ Hz $= 4.14 \times 10^{-5}$ eV
[6.98×10^{-24} J]

c) $f = 30$ MHz
$E = 4.136 \times 10^{-15}$ eV·sec $\cdot 30 \times 10^{6}$ Hz $= 1.24 \times 10^{-7}$ eV
[1.99×10^{-26} J]

3-9

~~2.8~~ For photons $f \cdot \lambda = c$ or $\lambda = \frac{c}{f}$

a) $f = 5 \times 10^{14}$ Hz
$$\lambda = \frac{3 \times 10^{8} \text{ m/sec}}{5 \times 10^{14} \text{ Hz}} = 6.00 \times 10^{-7} \text{ m}$$

b) $f = 10$ GHz ; $\lambda = 0.03$ m

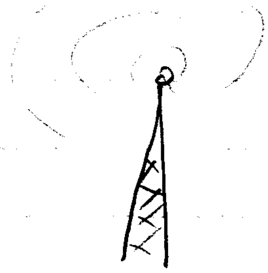
c) $f = 30$ MHz ; $\lambda = 10$ m

You could also use $E = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{E}$

3-10 ~~2-9~~

$P = 100\,kW$

$f = 94\,MHz$



For each photon, $E = hf$.

The number of photons emitted per second is

$$n = \frac{P}{hf} = \frac{100 \times 10^{3}\,W}{6.626 \times 10^{-34}\,J \cdot sec \cdot 94 \times 10^{6}\,Hz}$$

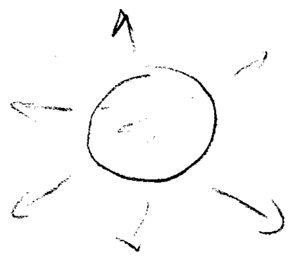
$$n = 1.6 \times 10^{30}\ sec^{-1}$$

3-11 ~~2-10~~

$P = 3.74 \times 10^{26}\,W$

$\lambda = 500\,nm$

$\Delta t = 1\,sec$



For each photon $E = hf = \frac{hc}{\lambda}$.

The number of photons emitted in 1 sec is

$$n = \frac{P}{\frac{hc}{\lambda}} \cdot \Delta t = \frac{3.74 \times 10^{26}\,W \cdot 1\,sec \cdot 500 \times 10^{-9}\,m}{6.626 \times 10^{-34}\,J \cdot sec \; 3 \times 10^{8}\,\frac{m}{sec}}$$

$$n = 9.41 \times 10^{44}$$