Problems

1. SMM, Chapter 2, Problem 2.

2. SMM, Chapter 2, Problem 3.

3. SMM, Chapter 2, Problem 4.

4. Calculate the energy of a photon whose frequency is (a) $5 \times 10^{14}$ Hz, (b) 10 GHz, (c) 30 MHz. Express your answers in electron volts. Also determine the corresponding wavelengths for each case and what part of the EM spectrum this is. (This is essentially SMM problem 2.7 & 2.8 combined).

5. SMM, Chapter 2, Problem 11.

6. Extra Credit problem 1. Using Planck’s spectral distribution formula, $u(\lambda, T)$, and recalling that $e_{\text{total}} = \frac{C}{4} \int_0^\infty u(\lambda, T) d\lambda$, derive Stefan’s law, $e_{\text{total}} = \sigma T^4$, for the total power per unit area radiated at all wavelengths. Work out the numerical value for the constant $\sigma$. Useful hint: $\int_0^\infty \frac{x^3}{(e^x - 1)} dx = \frac{\pi^4}{15}$.

7. Extra Credit problem 2. Using Planck’s spectral distribution formula, $u(\lambda, T)$, (a) Derive Wein’s displacement law, $\lambda_{\text{max}} T = \text{const}$. Assume that the transcendental equation, $x = 5(1 - e^{-x})$, has a non-trivial solution given by $x_0$. This comment will be clear are you work through the problem. (b) Using a dimensionless value for the non-trivial solution of $x_0 = 4.96511423$, work out the value and units of the constant.

Planck’s formula: $u(\lambda, T) = \frac{8\pi hc}{\lambda^5 \left(e^{\frac{hc}{\lambda kT}} - 1\right)}$, $u(f, T) = \frac{8\pi hf^3}{c^3 \left(e^{\frac{hf}{kT}} - 1\right)}$.