Chapter 2: The Quantum Theory of Light

2.2 Assume that your skin can be considered as a blackbody. We can use Wien's displacement law:

$$\lambda_{max} T = 2.898 \times 10^{-3} \text{ m.K}$$

When $T = 35°C = 308\ K \Rightarrow \lambda_{max} = \frac{2.898 \times 10^{-3}}{308}$

$$\Rightarrow \lambda_{max} = 9.41 \times 10^{-6} \text{ m} = \boxed{9410 \text{ nm}}$$

2.9

$$P = \frac{E}{t} = n\frac{hf}{t} \Rightarrow n = \frac{Pt}{hf}$$

$$t = 1 \text{ sec} \Rightarrow n = \frac{100 \times 10^{3}}{6.62 \times 10^{-34} \times 94 \times 10^{6}} = \boxed{1.6 \times 10^{30} \text{ photons/sec}}$$

2.14

In general $K = hf - \phi$

a) at the cut-off wavelength $K = 0 \Rightarrow \frac{hc}{\lambda_c} = \phi$

$$\Rightarrow \lambda_c = \frac{hc}{\phi} = \frac{1240 \text{ eV nm}}{4.2 \text{ eV}} = \boxed{295 \text{ nm}}$$

The threshold frequency is given by

$$f_0 = \frac{c}{\lambda_c} = \frac{3 \times 10^{8}}{295 \times 10^{-9}} = \boxed{1 \times 10^{15} \text{ Hz}}$$

b) $K = eV_s = hf - \phi$

$$\Rightarrow V_s = \frac{hf - \phi}{e} = \frac{hc}{\lambda e} - \frac{\phi}{e}$$

$$= \frac{1240\ \text{eV nm}}{200\ \text{nm} \times 1\ e} - \frac{4.2\ \text{eV}}{1\ e}$$

$$\boxed{V_s = 2.0\ \text{V}}$$

2.24

$E = 300 \times 10^3\ \text{eV}$ $\theta = 30°$ (scattering angle)

a) $$\Delta\lambda = \lambda' - \lambda_0 = \frac{h}{m_e c}(1 - \cos\theta)$$

$$= (0.00243\ \text{nm})(1 - \cos 30°) = \boxed{3.26 \times 10^{-4}\ \text{nm}}$$

b) $$E' = \frac{hc}{\lambda'}$$

$$\lambda' = \lambda_0 + \Delta\lambda = \frac{hc}{E} + \Delta\lambda = \frac{1240\ \text{eV nm}}{3 \times 10^5\ \text{eV}} + 3.26 \times 10^{-4}\ \text{nm}$$

$$= 4.46 \times 10^{-3}\ \text{nm}$$

$$\Rightarrow E' = \frac{1240\ \text{eV nm}}{4.46 \times 10^{-3}\ \text{nm}} = \boxed{2.78 \times 10^5\ \text{eV}}$$

c) $E = K_e + E' \Rightarrow K_e = E - E'$

$$= 3 \times 10^5 - 2.78 \times 10^5\ \text{eV}$$

$$= \boxed{22 \times 10^3\ \text{eV}}$$