

31. (a) When a photon scatters from an electron initially at rest, the change in wavelength is given by  $\Delta\lambda = (h/mc)(1 - \cos\phi)$ , where  $m$  is the mass of an electron and  $\phi$  is the scattering angle. Now,  $h/mc = 2.43 \times 10^{-12} \text{ m} = 2.43 \text{ pm}$ , so  $\Delta\lambda = (2.43 \text{ pm})(1 - \cos 30^\circ) = 0.326 \text{ pm}$ . The final wavelength is  $\lambda' = \lambda + \Delta\lambda = 2.4 \text{ pm} + 0.326 \text{ pm} = 2.73 \text{ pm}$ .
- (b) Now,  $\Delta\lambda = (2.43 \text{ pm})(1 - \cos 120^\circ) = 3.645 \text{ pm}$  and  $\lambda' = 2.4 \text{ pm} + 3.645 \text{ pm} = 6.05 \text{ pm}$ .