44. (a) From Eq. 39-11

$$\Delta\lambda = \frac{h}{m_e c}(1-\cos\phi) = (2.43\,\text{pm})(1-\cos 90°) = 2.43\,\text{pm}\ .$$

(b) The fractional shift should be interpreted as $\Delta\lambda$ divided by the original wavelength:

$$\frac{\Delta\lambda}{\lambda} = \frac{2.425\,\text{pm}}{590\,\text{nm}} = 4.11\times 10^{-6}\ .$$

(c) The change in energy for a photon with $\lambda = 590\,\text{nm}$ is given by

$$\begin{aligned}\Delta E_{\text{ph}} &= \Delta\left(\frac{hc}{\lambda}\right) \approx -\frac{hc\Delta\lambda}{\lambda^2} \\ &= -\frac{(4.14\times 10^{-15}\,\text{eV}\cdot\text{s})(2.998\times 10^8\,\text{m/s})(2.43\,\text{pm})}{(590\,\text{nm})^2} \\ &= -8.67\times 10^{-6}\ \text{eV}\ .\end{aligned}$$

For an x ray photon of energy $E_{\text{ph}} = 50\,\text{keV}$, $\Delta\lambda$ remains the same (2.43 pm), since it is independent of E_{ph}. The fractional change in wavelength is now

$$\frac{\Delta\lambda}{\lambda} = \frac{\Delta\lambda}{hc/E_{\text{ph}}} = \frac{(50\times 10^3\,\text{eV})(2.43\,\text{pm})}{(4.14\times 10^{-15}\,\text{eV}\cdot\text{s})(2.998\times 10^8\,\text{m/s})} = 9.78\times 10^{-2}\ ,$$

and the change in photon energy is now

$$\Delta E_{\text{ph}} = hc\left(\frac{1}{\lambda+\Delta\lambda} - \frac{1}{\lambda}\right) = -\left(\frac{hc}{\lambda}\right)\frac{\Delta\lambda}{\lambda+\Delta\lambda} = -E_{\text{ph}}\left(\frac{\alpha}{1+\alpha}\right)$$

where $\alpha = \Delta\lambda/\lambda$. We substitute $E_{\text{ph}} = 50\,\text{keV}$ and $\alpha = 9.78\times 10^{-2}$ to obtain $\Delta E_{\text{ph}} = -4.45\,\text{keV}$. (Note that in this case $\alpha \approx 0.1$ is not close enough to zero so the approximation $\Delta E_{\text{ph}} \approx hc\Delta\lambda/\lambda^2$ is not as accurate as in the first case, in which $\alpha = 4.12\times 10^{-6}$. In fact if one were to use this approximation here, one would get $\Delta E_{\text{ph}} \approx -4.89\,\text{keV}$, which does not amount to a satisfactory approximation.)