24.35 The grating spacing is $d = \frac{1}{3\,660}\text{ cm} = \frac{1}{3.66\times10^5}\text{ m}$ and $d\sin\theta = m\lambda$

(a) The wavelength observed in the first-order spectrum is $\lambda = d\sin\theta$, or

$$\lambda = \left(\frac{1\text{ m}}{3.66\times10^5}\right)\left(\frac{10^9\text{ nm}}{1\text{ m}}\right)\sin\theta = \left(\frac{10^4\text{ nm}}{3.66}\right)\sin\theta$$

This yields: at 10.1°, $\lambda = \boxed{479\text{ nm}}$; at 13.7°, $\lambda = \boxed{647\text{ nm}}$;

and at 14.8°, $\lambda = \boxed{698\text{ nm}}$

(b) In the second order, $m = 2$. The second order images for the above wavelengths will be found at angles $\theta_2 = \sin^{-1}(2\lambda/d) = \sin^{-1}[2\sin\theta_1]$

This yields: for $\lambda = 479$ nm, $\theta_2 = \boxed{20.5°}$; for $\lambda = 647$ nm, $\theta_2 = \boxed{28.3°}$;

and for $\lambda = 698$ nm, $\theta_2 = \boxed{30.7°}$

24.36 (a) The longest wavelength in the visible spectrum is 700 nm, and the grating spacing is $d = \frac{1\text{ mm}}{600} = 1.67\times10^{-3}\text{ mm} = 1.67\times10^{-6}\text{ m}$

Thus, $m_{max} = \frac{d\sin 90.0°}{\lambda_{red}} = \frac{(1.67\times10^{-6}\text{ m})\sin 90.0°}{700\times10^{-9}\text{ m}} = 2.38$

so $\boxed{\text{2 complete orders}}$ will be observed.

(b) From $\lambda = d\sin\theta$, the angular separation of the red and violet edges in the first order will be

$$\Delta\theta = \sin^{-1}\left[\frac{\lambda_{red}}{d}\right] - \sin^{-1}\left[\frac{\lambda_{violet}}{d}\right] = \sin^{-1}\left[\frac{700\times10^{-9}\text{ m}}{1.67\times10^{-6}\text{ m}}\right] - \sin^{-1}\left[\frac{400\times10^{-9}\text{ m}}{1.67\times10^{-6}\text{ m}}\right]$$

or $\Delta\theta = \boxed{10.9°}$

24.39 The grating spacing is $d = \dfrac{1\text{ cm}}{5\,000} = 2.00\times10^{-4}\text{ cm} = 2.00\times10^{-6}\text{ m}$, and $d\sin\theta = m\lambda$ gives the angular position of a second order spectral line as

$$\sin\theta = \frac{2\lambda}{d} \quad\text{or}\quad \theta = \sin^{-1}\left(\frac{2\lambda}{d}\right)$$

For the given wavelengths, the angular positions are

$$\theta_1 = \sin^{-1}\left[\frac{2\left(610\times10^{-9}\text{ m}\right)}{2.00\times10^{-6}\text{ m}}\right] = 37.6° \text{ and } \theta_2 = \sin^{-1}\left[\frac{2\left(480\times10^{-9}\text{ m}\right)}{2.00\times10^{-6}\text{ m}}\right] = 28.7°$$

If L is the distance from the grating to the screen, the distance on the screen from the central maximum to a second order bright line is $y = L\tan\theta$. Therefore, for the two given wavelengths, the screen separation is

$$\Delta y = L\left[\tan\theta_1 - \tan\theta_2\right]$$

$$= (2.00\text{ m})\left[\tan(37.6°) - \tan(28.7°)\right] = 0.445\text{ m} = \boxed{44.5\text{ cm}}$$

24.53 From Malus's law, the intensity of the light transmitted by the first polarizer is $I_1 = I_i\cos^2\theta_1$. The plane of polarization of this light is parallel to the axis of the first plate and is incident on the second plate. Malus's law gives the intensity transmitted by the second plate as $I_2 = I_1\cos^2(\theta_2 - \theta_1) = I_i\cos^2\theta_1\cos^2(\theta_2 - \theta_1)$. This light is polarized parallel to the axis of the second plate and is incident upon the third plate. A final application of Malus's law gives the transmitted intensity as

$$I_f = I_2\cos^2(\theta_3 - \theta_2) = I_i\cos^2\theta_1\cos^2(\theta_2 - \theta_1)\cos^2(\theta_3 - \theta_2)$$

With $\theta_1 = 20.0°$, $\theta_2 = 40.0°$, and $\theta_3 = 60.0°$, this result yields

$$I_f = (10.0\text{ units})\cos^2(20.0°)\cos^2(20.0°)\cos^2(20.0°) = \boxed{6.89\text{ units}}$$

24.54 (a) Using Malus's law, the intensity of the transmitted light is found to be

$$I = I_0\cos^2(45°) = I_0\left(1/\sqrt{2}\right)^2, \text{ or } \boxed{I/I_0 = 1/2}$$

(b) From Malus's law, $I/I_0 = \cos^2\theta$. Thus, if $I/I_0 = 1/3$ we obtain

$$\cos^2\theta = 1/3 \quad\text{or}\quad \theta = \cos^{-1}\left(1/\sqrt{3}\right) = \boxed{54.7°}$$