By definition,

$$\varepsilon*(\omega) = \varepsilon'(\omega) - j\varepsilon''(\omega) = A + \frac{B}{\left[\left(\omega_0^2 - \omega^2\right) + j\omega\gamma\right]}$$

$$= A + \frac{B}{\left[\left(\omega_0^2 - \omega^2\right) + j\omega\gamma\right]} \cdot \frac{\left[\left(\omega_0^2 - \omega^2\right) - j\omega\gamma\right]}{\left[\left(\omega_0^2 - \omega^2\right) - j\omega\gamma\right]}$$

Therefore we have that $\varepsilon'(\omega) = A + \dfrac{B\left(\omega_0^2 - \omega^2\right)}{\left[\left(\omega_0^2 - \omega^2\right)^2 + \omega^2\gamma^2\right]}$ , $\varepsilon''(\omega) = \dfrac{\omega\gamma B}{\left[\left(\omega_0^2 - \omega^2\right)^2 + \omega^2\gamma^2\right]}$

$\omega_o$ is clearly in the IR region so high $\omega$ compared to this is in the visible optical or UV region beyond. Below UV, but above IR, we expect the electronic contribution to the permittivity to be constant. In this region we in effect have:

$$\varepsilon'(\omega) \to A - \frac{B\omega^2}{\omega^4 + \omega^2\gamma^2} \to A - \frac{B}{\omega^2} \to \qquad A = n^2 = \underline{\underline{4}}$$

The refractive index in the visible region was given as $n = 2$ and $\varepsilon = n^2$.

At very low frequencies i.e. as $\omega \to 0$ we have that the $\omega_0^2$ term dominates and we have

$$\varepsilon'(\omega) \to A + \frac{B\omega_0^2}{\omega_0^4} = A + \frac{B}{\omega_0^2} = 10 \qquad \therefore B = (10 - A)\omega_0^2 = (10 - 4).64 \times 10^{24} = \underline{\underline{3.84 \times 10^{26} \, s^{-2}}}$$

In practice, $\varepsilon''(\omega)$ peaks at $\approx \omega_0$ (in fact, a little below this - this was stated in lectures for this type of sharp resonant-type process) so we have:

$$\varepsilon''(\omega) = 30 \approx \frac{\omega_0\gamma B}{\omega_0^2\gamma^2} = \frac{B}{\omega_0\gamma} = \frac{3.84 \times 10^{26}}{8 \times 10^{12}\gamma} \qquad \therefore \gamma \approx \frac{3.84 \times 10^{26}}{8 \times 10^{12} \times 30} = \underline{\underline{1.6 \times 10^{12} \, s^{-1}}}$$

Clearly the resonant form of $\varepsilon*(\omega)$ in the IR region indicates that this is characteristic of a typical ionic vibrational mode and as silicon is not ionic then ZnS is much more likely to be indicated (although the numbers do NOT actually correspond to those for ZnS).

In practice, differentiation of $\varepsilon''(\omega)$ wrt $\omega$ leads to $3\omega^4 + \omega^2\gamma^2 - 2\omega^2\omega_0^2 - \omega_0^4 = 0$ as the condition for the position of the maximum in $\varepsilon''(\omega)$. Simply putting in the above estimated value of $\gamma$ suggests a value of $\omega = 7.96 \times 10^{12} \, s^{-1}$ for the peak which is fairly consistent and hence justifies the actual use of $\omega_0$ instead of trying to solve the above equation.