1. A crystal is opaque for light with wavelengths $\lambda < 413$ nm. For longer wavelengths it is transparent. Determine the band gap of the crystal in eV.

$$E_g = \frac{1.24}{0.413} \times 1 \text{ eV} = 3 \text{ eV}$$

4 eV $\Rightarrow$ 1.24 $\mu$m

2. Consider a symmetric pn junction formed by joining a p-doped and an n-doped pieces of Si on the left and right, respectively (see the drawing). The width of the depletion region is $W = 1.4 \mu$m. It is known that the net potential barrier across the depletion region (that is, on going from left to right) is $\Delta V = 0.6 \text{ V}$. Find the built-in electric field (in the units of V/m) exactly at the junction (that is, at the interface).

$$W = x_2 - x_1$$

$$E(x) = \begin{cases} 
-E_0 \cdot \frac{x}{x_1} + E_0, & x_1 < x < 0 \\
-E_0 \cdot \frac{x}{x_2} + E_0, & 0 < x < x_2 
\end{cases}$$

$$E(x) = 0 \text{ elsewhere}$$

$$\Delta V = \int_{x_1}^{x_2} E(x) \, dx = \int_{x_1}^{x_2} \left(-\frac{E_0}{x_1} \cdot x + E_0\right) \, dx = \frac{E_0}{2} (x_2 - x_1) = \Delta V, \Rightarrow E_0 = \frac{2 \Delta V}{W} = \frac{0.857 \text{ MV}}{\text{m}}$$

3. Assume that a pn-junction diode is described by W. Shockley's equation relating the current through the diode, $I$, with the voltage applied across the diode, $V$. The saturation current of the diode (that is, the current flowing in reverse biasing polarity) is known: $I_{sat} = 1 \mu A$ (at room temperature). Calculate the current that would flow through the diode in the forward biasing polarity at $V = 0.1 \text{ V}$ (also at room temperature).

**Shockley's diode equation:**

$$I = I_{sat} \cdot \left(e^{\frac{eV}{kT}} - 1\right),$$

where

$\text{If}_{\text{sat}} = 1 \mu A$, $kT$ at room temperature is 0.026 eV.

Thus, $I = 1 \mu A \cdot (e^{\frac{0.1 \text{ eV}}{0.026 \text{ eV}}} - 1) = 45.8 \mu A$. 