1. Each In atom will attract an electron and thus create a "mobile hole"; we only have to determine the number of In atoms/cm^3. The atomic volume of the host crystal (Ge) is given on your PT as 13.57 cm^3/mole.

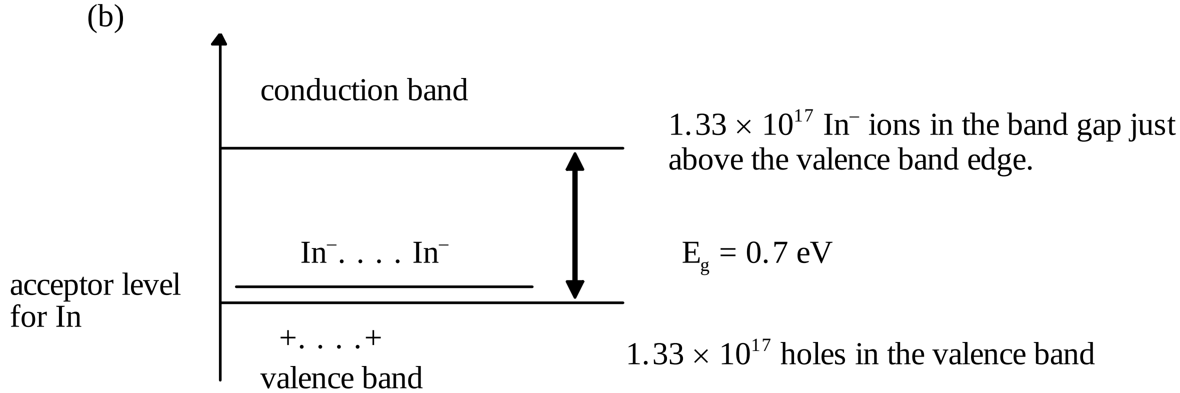
(a) # Ge atoms/cm^3 = $\dfrac{6.02\times10^{23}\ \text{atoms}}{1\ \text{mole}}\times\dfrac{1\ \text{mole}}{13.57\ \text{cm}^3}$

$= 4.44 \times 10^{22}$ atoms/cm^3

In atoms/cm^3 = $4.44 \times 10^{22} \times 0.0003 \times 10^{-2} = 1.33 \times 10^{17}$ In/cm^3

The number of free charge carriers ("holes") is 1.33×10^{17}/cm^3; they are created through the acquisition of one electron by each In atom from the valence band of the host crystal.

(b)



2. $$\lambda_{crit} = \frac{hc}{E_g} = \frac{6.62\times10^{-34}\times3\times10^{8}}{1.1\times1.6\times10^{-19}} = 1.13\times10^{-6}\ \text{m}$$

The critical λ for silicon is 1.1×10^{-6} m; thus radiation of $\lambda = 5 \times 10^{-7}$ m $= 0.5 \times 10^{-6}$ m has even more energy than that required to promote electrons across the band gap.

3. We determine the atomic (molar) volume of Si (PT); thus we know the total number of As atoms required, and convert that number into number of grams of As:

Si (Atomic Volume): At.Wt./ρ = 12.1×10^{-6} m^3/mole

# of As atoms required = $12.1 \times 5 \times 10^{17} = 6.1 \times 10^{18}$ As/mole of Si

g of As required: 6.1×10^{18} As atoms $\times$ {74.92 g/(6.02×10^{23})}

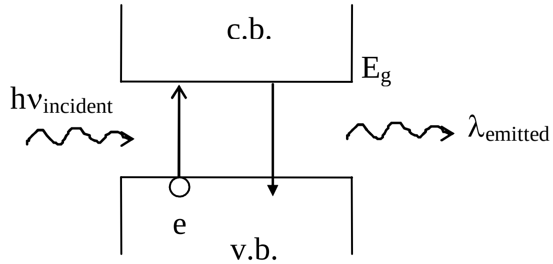
= 7.59×10^{-4} g As

4. (a) First compare E of the incident photon with E_g:

$E_{incident\ photon} = h\nu = 6.6 \times 10^{-34} \times 3.091 \times 10^{14} = 2.04 \times 10^{-19}$ J

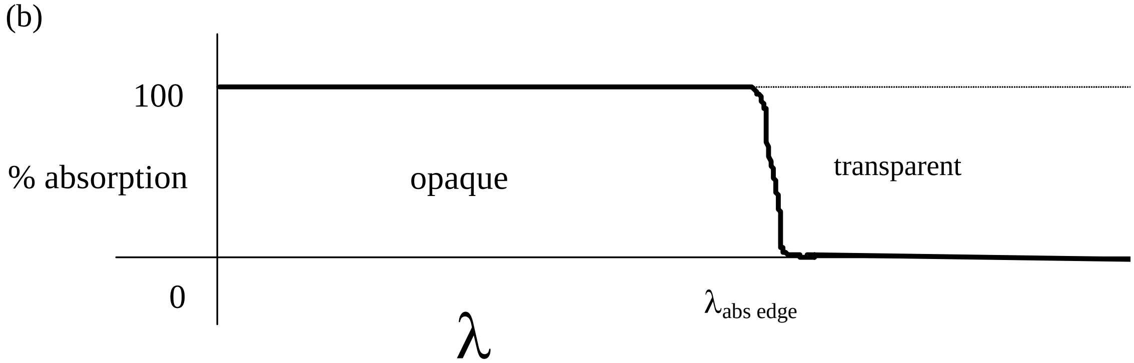
$E_g = 0.7$ eV $= 1.12 \times 10^{-19}$ J $< E_{incident\ photon}$

∴ electron promotion followed by emission of a new photon of energy equal to E_g
- energy in excess of Eg is dissipated as heat in the crystal



$$\lambda_{emitted} = \frac{hc}{E_g} = \frac{6.6\times10^{-34}\times3\times10^{8}}{0.7\times1.6\times10^{-19}} = 1.77\times10^{-6}\,\text{m}$$

(b)



$\lambda_{abs\ edge} = \lambda_{emitted}$ as calculated in part (a) = 1.77 μm

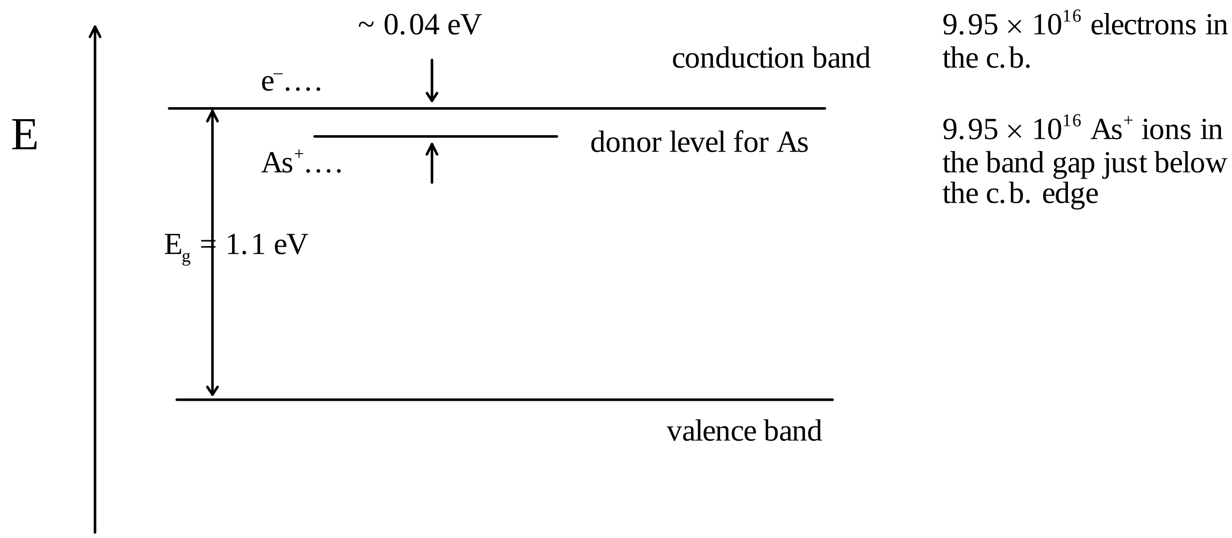
5. Each As atom will donate a free electron to the conduction band; we only have to determine the number of As atoms/cm^3. The molar volume of Si is given on your PT as V_{molar} = 12.1 cm^3/mole.

(a) # Si atoms/cm^3 $= \frac{6.02\times10^{23}\ \text{atoms}}{1\ \text{mole}} \times \frac{1\ \text{mole}}{12.1\ \text{cm}^3} = 4.98\times10^{22}$ atoms/cm^3

As atoms/cm^3 $= 4.98\times10^{22}\times0.0002\times10^{-2} = 9.95\times10^{16}$ As/cm^3

free charge carriers is 9.95×10^{16}/cm^3.

(b)



6. PT gives molar volume of Ge as 13.57 cm^3 and 1 mole of Ge weighs 72.61 g

set up ratio: $\frac{72.61}{13.6} = \frac{1000\ \text{g}}{x}$ and solve for x to get 187.30 cm^3

addition of boron gives 1 charge carrier/B atom

+ B concentration in Si must be 3.091×10^{17} B/cm^3

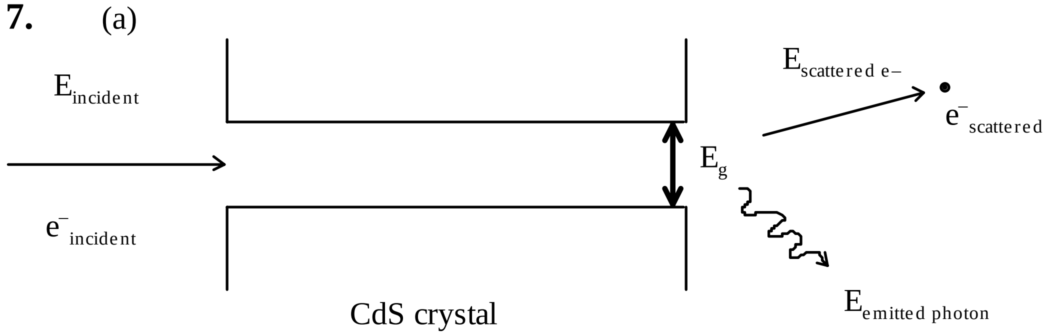
N_{av} B atoms weigh 10.81 g

$\therefore$ 3.091×10^{17} B atoms weigh $\frac{3.091 \times 10^{17}}{6.02 \times 10^{23}} \times 10.81 = 5.55 \times 10^{-6}$ g

$\therefore$ to 1 cm^3 of Ge, add 5.55×10^{-6} g B

+ to 187.30 cm^3 of Ge, add $187.30 \times 5.55 \times 10^{-6} = 1.04 \times 10^{-3}$ g B

7. (a)



$E_{\text{incident e}-} = E_{\text{emitted photon}}\ (=E_g) + E_{\text{scattered e}-} = E_g + \frac{1}{2} mv^2$

$$= 2.45\ \text{eV} + \frac{1}{2} \times \frac{9.11 \times 10^{-31}\ \text{kg} \times \left(4.4 \times 10^{5}\ \text{m/s}\right)^2}{1.6 \times 10^{-19}\ \text{eV/J}}$$

$= 2.45\ \text{eV} + 0.55\ \text{eV} = 3.00\ \text{eV}$

(b) $E_g(CdTe) < E_g(CdS)$

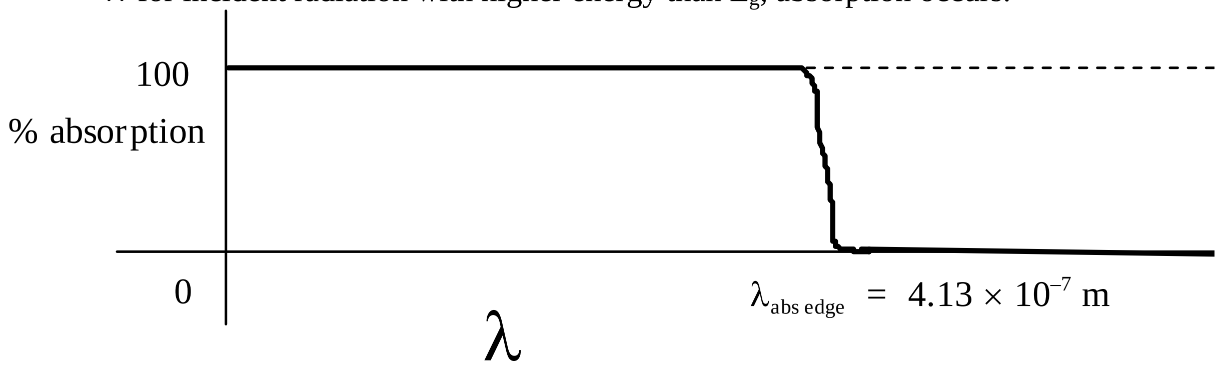
the Cd–S bond is stronger than Cd–Te bond because although both S and Te are group 16, Te is much larger than S

8. (a) first calculate the absorption edge:

$$E_g = \frac{hc}{\lambda_{abs\ edge}} \quad + \quad \lambda_{abs\ edge} = \frac{hc}{E_g} = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{3.0 \times 1.6 \times 10^{-19}}$$

$$= 4.13 \times 10^{-7}\ \text{m}$$

$\therefore$ for incident radiation with higher energy than E_g, absorption occurs.



(b) $E_g(AlSb) < E_g(AlP)$

the Al–P bond is stronger than Al–Sb bond because although both P and Sb are group 15, Sb is much larger than P.

9. (i) You need to dope with an electron donor, which means an element from Group 15. So this gives you P, As, Sb as candidates.

(ii) The majority charge carrier is the electron, which moves in the conduction band.

(iii) See answer to 5 (b).