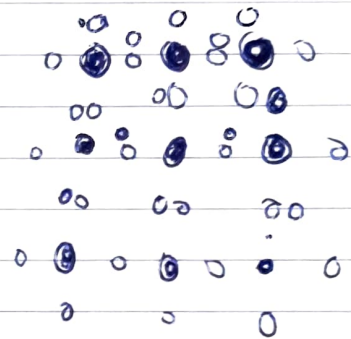
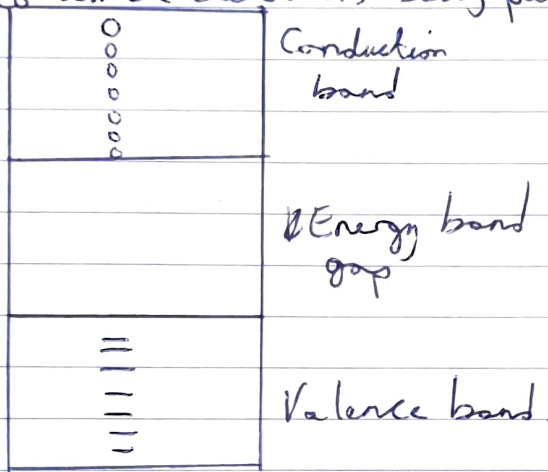


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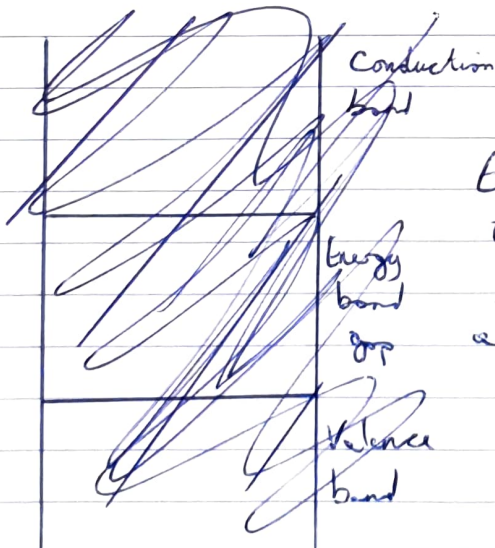
1) A). When atoms come together to form a solid, ~~as a result~~ their valence electrons interact with each other.

As a result valence electrons of atoms at different energy levels get split into different electron states, and form electron energy bands.

B. This leads to equal number of holes to electrons due to all the electrons being paired up and no free electrons or holes being formed.



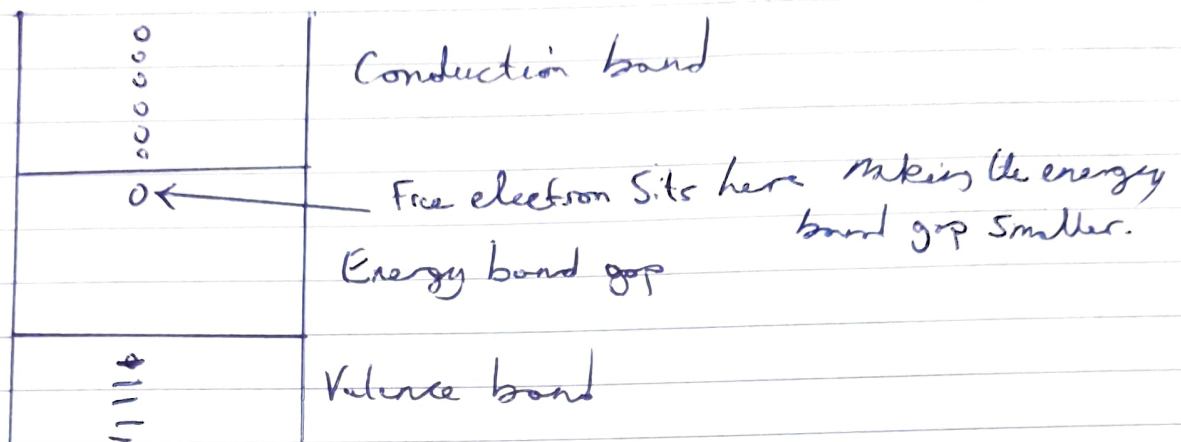
C.



To make an n-type extrinsic Semiconductor you would need to add a group 5 Material this then would allow there to be a free electrons. This provides a charge carrier.

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- D. This then Increases the Negative charges by having a higher concentration of electrons than holes



- e.) i) A Compound is a thing that is composed of two or more separate elements, such as SiC such as gallium arsenide and silicon germanium.
- ii) Elemental is when something is uncombined or on its own so far any chemical process has occurred such as adding silicon and germanium together.

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- 2). When a Semi Conductor which has 4 atoms in the outer shell is paired (Silicon) is paired with a material which is group 3 (3 in outer shell) Boron. ~~A gap is formed when this gap is~~ This now leaves a hole in the in Valence band of the Silicon atoms. Therefore the electrons in the Valence band become mobile and move in the opposite direction to the electrons. This makes this a p-type Semiconductor.

- 3).

2.5 Silicon	2.5×10^{19}	Weight Si = 28.09
germanium	1.8×10^{21}	Ge = 72.59
Density Ge	5.32	
Si	2.33	

$$S_i = \frac{6.022 \times 10^{23} \times 2.33 \times 10^6}{28.09} = 4.995 \times 10^{28} \text{ atom/m}^3$$

$$G_e = \frac{6.022 \times 10^{23} \times 5.32 \times 10^6}{72.59} = 4.41 \times 10^{28} \text{ atom/m}^3$$

$$S_i = \frac{\text{Number electrons}}{\text{Number of atoms}}$$

$$S_i = \frac{2.5 \times 10^{19}}{4.995 \times 10^{28}} = 5.01 \times 10^{-10} \text{ e/atom}$$

$$G_e = \frac{1.8 \times 10^{21}}{4.41 \times 10^{28}} = 4.082 \times 10^{-8} \text{ e/atom}$$

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5).

$$\mu_h = \frac{\text{Drift Velocity}}{\text{Electric field}} = \frac{175}{1250} = 0.14$$

$$\sigma = n \times e \times \mu_h = 8 \times 10^{14} \text{ m}^{-3} \times 1.6 \times 10^{-19} \times 0.14$$

$$\sigma = 1.792 \times 10^{-5} \text{ } \Omega \text{ m}^{-1}$$

$$6). \quad \sigma = C T^{\frac{3}{2}} \exp\left(\frac{-e\phi}{2kT}\right)$$

$$\ln \sigma = \ln C - \frac{3}{2} \ln T - \frac{e\phi}{2kT}$$

$$\ln C = \ln \left(\frac{2 \times 10^4}{\text{m}^3} \right) + \left(\frac{3}{2} \right) \ln 298 + \frac{0.17}{2 \times (8.62 \times 10^{-5}) \times 298}$$

$$\ln C = 84.63$$

$$\ln \sigma = 84.63 - \frac{3}{2} \ln(478) + \frac{0.17}{2 \times (8.62 \times 10^{-5}) \times 478}$$

$$\ln \sigma = 73.31$$

$$\sigma = 6.91 \times 10^{31} \text{ } \Omega \text{ m}^{-1}$$

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- 7)
- i) Monochromatic - of a single wavelength or frequency
 - ii) Coherent - Same frequency and are all the same frequency. The waves are identical and in phase.
 - iii) Directional - All the light is emitted in the same direction from the source allowing it to stay very focused over long distances.
- b) Stimulated emission is the process which an incoming photon of a specific frequency can interact with an excited atomic electron causing it to drop to a lower energy level.
- ii) Population inversion is the redistribution of atomic energy levels that takes place in a system so that laser action can occur. ~~There are always more atoms in low energy states than in higher ones.~~
- c) In a 4 level laser, only a few electrons are excited to achieve population inversion. So a 4 level laser produces light more efficiently than a 3 level laser. In a four level laser, a laser beam can be achieved by using atoms that have two stable levels between their ground state and higher energy excited state. In a three level system they are excited to a short lived high energy state, they then quickly decay to the intermediate metastable level. Population inversion happens between lower ground state and higher energy state.

$$8). i). 2.29 \times 10^{-19} - 0.42 \times 10^{-19} J = 1.87 \times 10^{-19}$$

$$E = hf = \frac{hc}{\lambda} =$$

$$1.87 \times 10^{-19} = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{\lambda}$$

$$\lambda = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{1.87 \times 10^{-19}}$$

$$= 1.064 \times 10^{-6} \text{ m}$$

- ii) Absorption is how the electron absorbs energy of an incoming photon. Absorption can only occur if the energy of the incoming photon is exactly equal to the difference in energy of the two energy levels.

$$\sigma = P \mu_n / e / u_e \mu_L$$

$$4) A. \quad n = \frac{\sigma}{e \mu_n}$$

$$P = \frac{\sigma}{e \mu_L}$$

$$\frac{33.5}{1.6 \times 10^{-19} \times 0.06}$$

$$= 3.49 \times 10^{21}$$

$$\frac{33.5}{1.6 \times 10^{-19} \times 0.02}$$

$$= 1.047 \times 10^{22}$$

13). P This is a P type conductor due to ~~large~~ ^{high} p concentration being higher than n. More holes than electrons.