PHYS 3202 QPII

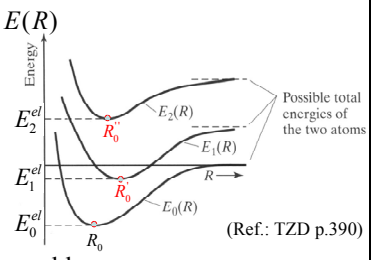
Corrections are in red color:

(will be updated if necessary)

Ch.1, p.8, 8th box

When one or more of the valence electrons are excited, the molecule is in the excited states and for these states, the $E(R)$ curves also have minimum values:

$E_1^{el}, E_2^{el}, \ldots$ at certain R, as shown schematically by the graph:



(Ref.: TZD p.390)

Now we further simplify the problem:

- All physics is dominated by what happens near the minimum of $E(R)$.
- Now we allow R to change only slightly around R_0, i.e., $R \approx R_0$.

Ch.1, p.10, 5th box

- **Line intensities** of rotational spectrum are determined by
  1. selection rules
  2. degeneracy of each level (with quantum number ℓ)
  3. thermal occupation probability of the levels. (Appendix 4)

Population of a level:

$$N_\ell = \underbrace{(2\ell+1)}_{\text{degeneracy}}\underbrace{(e^{-E_\ell^{rot}/k_BT})}_{\text{probability}}$$

For small ℓ, the degeneracy factor is small while for large ℓ, the thermal factor is small.

$\Rightarrow$ Temperature of molecules can be determined by the line intensities.

The line with maximum intensity can be found by taking

$$\frac{dN_\ell}{d\ell} = 0 \quad \Rightarrow 2\ell+1 \approx \sqrt{\frac{4\mu R_0^2 k_B T}{\hbar^2}}$$

Ch.1, p.1, 8th box

$$\hat{H} = -\frac{\hbar^2}{2M_1}\nabla^2_{\vec{R}_1} - \frac{\hbar^2}{2M_2}\nabla^2_{\vec{R}_2} \quad (1)$$

$$+\sum_{i=1}^{Z_1}\left[-\frac{\hbar^2}{2m}\nabla^2_{\vec{r}_{1i}}\right] + \sum_{i=1}^{Z_2}\left[-\frac{\hbar^2}{2m}\nabla^2_{\vec{r}_{2i}}\right] \quad (2)$$

$$+\frac{Z_1 Z_2 e^2}{4\pi\varepsilon_0 |\vec{R}_1 - \vec{R}_2|} \quad (3)$$

$$+\sum_{i=1}^{Z_1}\left[-\frac{Z_1 e^2}{4\pi\varepsilon_0}\frac{1}{|\vec{r}_{1i} - \vec{R}_1|}\right] + \sum_{i=1}^{Z_2}\left[-\frac{Z_2 e^2}{4\pi\varepsilon_0}\frac{1}{|\vec{r}_{2i} - \vec{R}_2|}\right] + \quad (4)$$

$$+\sum_{i=1}^{Z_1}\left[-\frac{Z_2 e^2}{4\pi\varepsilon_0}\frac{1}{|\vec{r}_{1i} - \vec{R}_2|}\right] + \sum_{i=1}^{Z_2}\left[-\frac{Z_1 e^2}{4\pi\varepsilon_0}\frac{1}{|\vec{r}_{2i} - \vec{R}_1|}\right] + \ldots$$

$$+\sum_{i=1,j=1}^{Z_1 Z_2}\frac{e^2}{4\pi\varepsilon_0 |\vec{r}_{1i} - \vec{r}_{2j}|} + \ldots \quad (5)$$

[1]

This is a many-body QM problem.

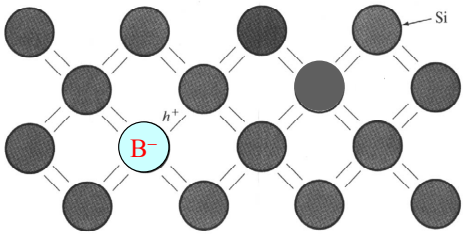
Very difficult but not hopeless!

Ch.2, p.13, 6th box

p-type *semiconductor*

Acceptors for Si: Group III elements (B, Al, Ga, In), e.g. each B atom has 3 electrons ($2s^2 2p^1$) and thus it can capture one electron from the **VB**, & thus create a hole in **VB**.

(Electrons in **VB**: Si sp^3 electrons)



It needs only a small energy to remove one electron from a nearby Si atom and bind it to the acceptor atom.

The ionized acceptors are (immobile) negative ions.

Ch.2, p.16, 4th box

Charge neutrality: total charge = $Q_+ + Q_- = 0$

$$\Rightarrow W_n N_d^+ = W_p N_a^-$$

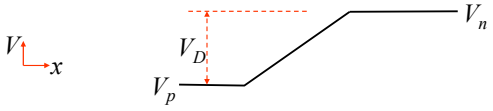
By solving Poisson's equation, you can get W_p & W_n and the total width of depletion layer = $W = W_p + W_n$

(See e.g. Solid State Electronic Devices, p.166)

$$W = \left[\frac{2\varepsilon V_D}{e}\left(\frac{1}{N_a^-} + \frac{1}{N_d^+}\right)\right]^{1/2}$$

[22]

The electric field sets up a potential across the depletion layer,

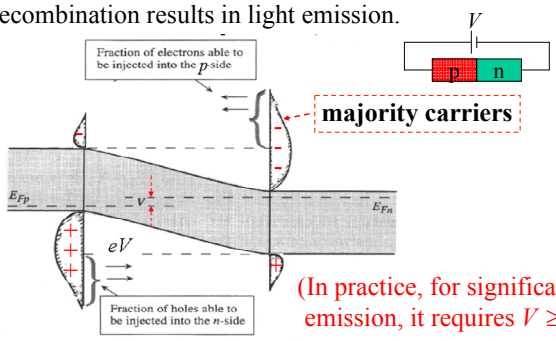


and thus bends the energy bands.

Ch.2, p.17, 3rd box

In p-n junction, excess charge carriers can be easily ***injected*** into the depletion layer by means of forward bias.

Recombination results in light emission.



(In practice, for significant light emission, it requires $V \geq V_D$.)

- First semiconductor laser was invented in 1962:
  GaAs p-n junction (infrared light)
  GaAsP p-n junction (visible light)