Lecture 11 – Worksheet: Absorption and Emission Spectroscopy

Model 1: Electronic Absorption Spectroscopy

The Jablonski diagram overleaf shows the vibrational energy levels of two electronic state, S_0 and S_1 of a molecule. The vibrational levels and their energies are labelled. The electronic *absorption* spectrum corresponds to the transitions from the energy levels of state S_0 to the energy levels of state S_1.

Critical Thinking Questions

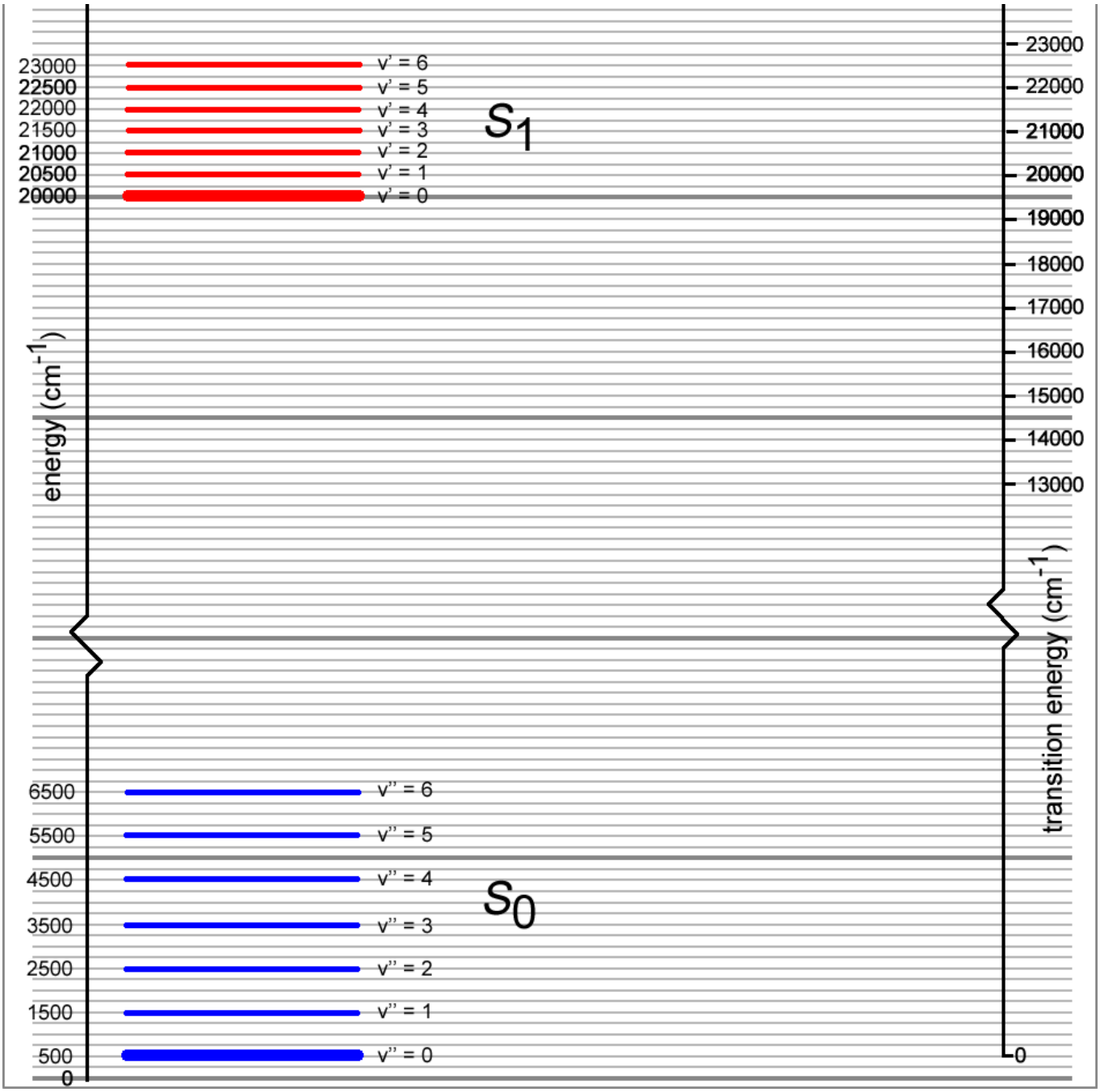
1. Why does the lowest energy level of S_0 **not** occur at 0 cm^{-1}?
2. What is the vibrational spacing in the ground state, S_0?
3. What is the vibrational spacing in the excited state, S_1?
4. At room temperature, almost all of the molecules will be in the lowest level of S_0, $v'' = 0$. From this level, draw arrows from this level up to each of the energy levels of S_1.
5. The energy of the absorbed light corresponds to the length of the arrow. Trace across to the **axis on the right** and mark where each transition occurs and its assignment.

Model 2: Emission Spectrum

The emission spectrum corresponds to the transitions from the energy levels of state S_1 to the energy levels of state S_0.

Critical Thinking Questions

1. Emission occurs from the lowest vibrational level of S_1, $v' = 0$. Draw arrows from this level *down* to each of the energy levels of S_0.
2. The energy of the emitted light corresponds to the length of the arrow. This can be obtained by taking the *difference* between the energies of the two levels involved. Calculate these and mark the positions of the emission lines on the axis on the right. Assign each line.


23000
22500
22000
21500
21000
20500
20000
v' = 6
v' = 5
v' = 4
v' = 3
v' = 2
v' = 1
v' = 0
S1
energy (cm-1)
6500
5500
4500
3500
2500
1500
500
0
v'' = 6
v'' = 5
v'' = 4
v'' = 3
v'' = 2
v'' = 1
v'' = 0
S0
23000
22000
21000
20000
19000
18000
17000
16000
15000
14000
13000
transition energy (cm-1)
0