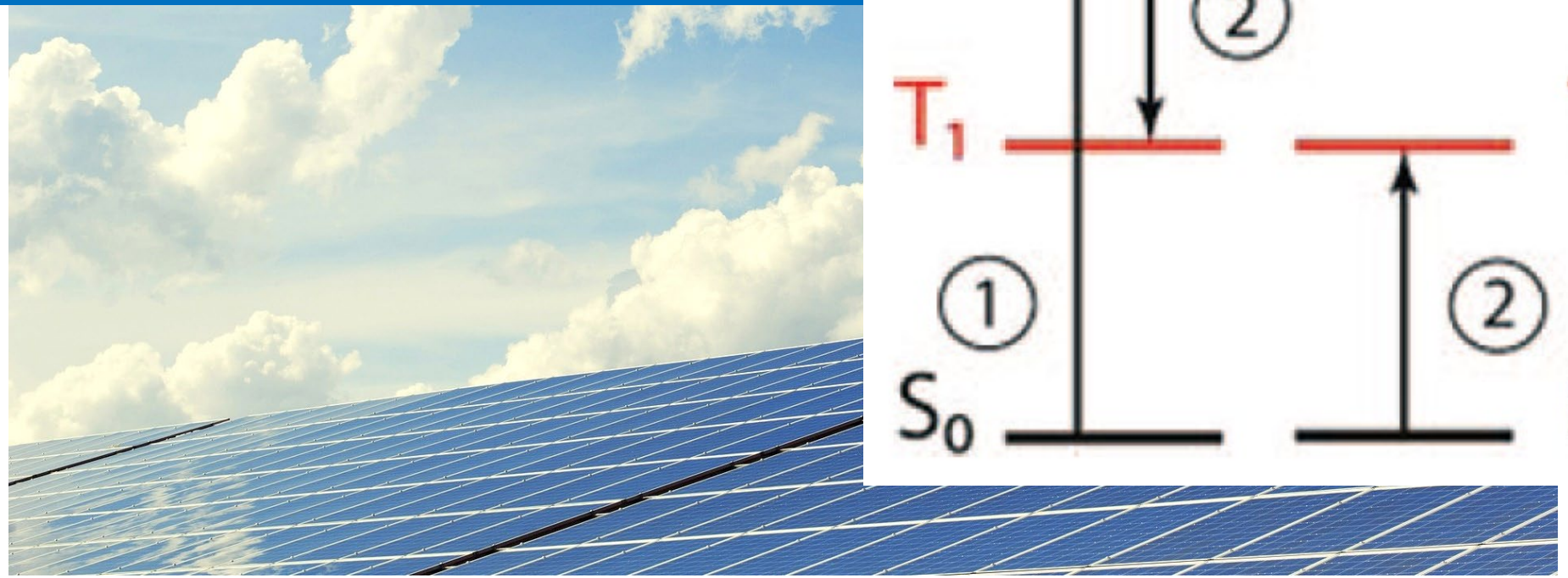
Quiz 3

Singlet Fission



Singlet fission is a process by which an excited state singlet in one molecule transfers energy to a neighbouring molecule, and in the process converts to two triplet states (one on each molecule). This process is helpful in harnessing energy from the sun.

Explain clearly how it is possible that this process conserves spin, i.e., that the quantum numbers, s and m_s, corresponding to the total spin, remain unchanged during the singlet fission process.

Solutions:

We consider the addition of two s = 1 particles (the two triplet states, $s_1 = s_2 = 1$).

$$1 \otimes 1 = 2 \oplus 1 \oplus 0$$

$s_{min}^{tot} = |s_1 - s_2| = 0$ corresponds to a singlet state in the coupled representation.

Since we started with a singlet state, it must be that $s^{tot} = 0$ for the spin quantum number s to be conserved.

The singlet state has m = 0. This can be achieved by considering linear combinations of the following:

$$|s_1 = 1, m_1 = 1, s_2 = 1, m_2 = -1\rangle, |s_1 = 1, m_1 = -1, s_2 = 1, m_2 = 1\rangle, |s_1 = 1, m_1 = 0, s_2 = 1, m_2 = 0\rangle$$

(FYI:) According to the Clebsch-Gordan table,

$$|s = 0, m = 0, s_1 = 1, s_2 = 1\rangle$$
$$= \frac{1}{\sqrt{3}}(|s_1 = 1,\ m_1 = 1,\ s_2 = 1,\ m_2 = -1\rangle - |s_1 = 1,\ m_1 = 0,\ s_2 = 1,\ m_2 = 0\rangle + |s_1 = 1,\ m_1 = -1,\ s_2 = 1,\ m_2 = 1\rangle)$$