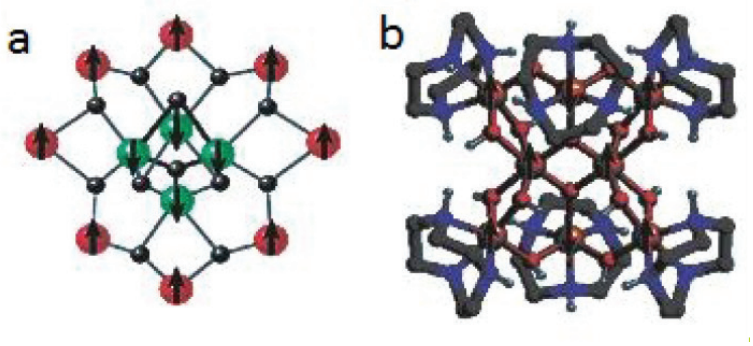
Tutorial 2

1. **Molecular Magnets**

   A molecular magnet is an organic molecule that behaves like a tiny magnet due to its spin. The structure of one such molecule is shown in the figure.



   Consider a molecule with spin $s = 2$. The approximate Hamiltonian describing the time dynamics for this molecule is

$$\hat{H} = -\left(\frac{D}{\hbar}\right)\hat{S}_z^2,$$

   where D is an anisotropy constant.

   (a) Write the Hamiltonian in the Zeeman basis (basis of eigenstates of $\hat{S}_z$).

   (b) What is the ground state energy of the molecule, and what is its degeneracy?

   (c) Using

$$\hat{S}_\pm |s, m_s\rangle = \sqrt{s(s+1) - m_s(m_s \pm 1)}\,\hbar\,|s, m_s \pm 1\rangle,$$

   find the matrix representation of $\hat{S}_+^2 + \hat{S}_-^2$.

   (d) If the exact Hamiltonian is

$$\hat{H} = -\left(\frac{D}{\hbar}\right)\hat{S}_z^2 + \left(\frac{A}{\hbar}\right)(\hat{S}_+^2 + \hat{S}_-^2)$$

   and initial state is $|s, m_s\rangle = |2, 1\rangle$, what is the state after time t?