

## M04Q.1—Hydrogen Molecule

### Problem

Consider a hydrogen molecule  $\text{H}_2$ . Write down the Hamiltonian, keeping only the kinetic energy terms and the Coulomb interactions of all the constituents and omitting terms which cause fine and hyperfine structure.

- a) What is the degeneracy of the ground state? Give all quantum numbers and symmetries of the ground state(s), including the electron and proton degrees of freedom.
- b) What is the degeneracy, and what are all the quantum numbers of the first excited state of this  $\text{H}_2$  molecule? Explain.
- c) What is the energy difference between ground and first excited states? Estimate it first through a formula, in terms of properties of the molecule's ground state, and then in electron-Volts (eV).