

1. Evidence for the electron spin was provided by the Stern–Gerlach experiment. Sketch and briefly describe the key features of the experiment. Explain what was observed and how this observation may be interpreted in terms of electron spin. (20%)
2. The mean time for a spontaneous  $2p \rightarrow 1s$  transition is  $1.6 \times 10^{-9}$  second while the mean time for a spontaneous  $2s \rightarrow 1s$  transition is as long as 0.14 second. Explain. (20%)
3. Carbon monoxide (CO) absorbs energy at  $1.153 \times 10^{11}$  Hz, due to a transition between the  $l = 0$  and  $l = 1$  rotational states. (20%)
  - (a) What is the corresponding wavelength? In which part of the electromagnetic spectrum does this lie? (5%)
  - (b) What is the energy (in eV)? (5%)
  - (c) Calculate the reduced mass  $\mu$ . ( $C = 12$  times, and  $O = 16$  times the unified atomic mass constant.) (5%)
  - (d) Given that the rotational energy  $E = \frac{l(l+1)\hbar^2}{2\mu r^2}$ , find the interatomic distance  $r$  for this molecule. (5%)
4. Consider a particle of mass  $m$  trapped in a potential well of finite depth  $V_0$ . Discuss the solutions and eigenvalues for the class I and II solutions graphically. (Hint:  $V(x) = V_0, |x| > a$ ;  $V(x) = 0, |x| < a$ .) (20%)
5. If a rod travels with a speed  $v = 0.8c$  along its length, how much does it shrink? (20%)