

BOTTOM LINE ANSWERS: PHYS30101 JANUARY 2017

Question 1 (e)

(i) $\widehat{H} = \frac{eB}{m}\widehat{S}_z$ Eigenvalues $\pm \frac{e\hbar B}{2m}$

(ii) $\Psi(t) = \frac{1}{\sqrt{17}} [\alpha_z e^{-i\omega t} + 4i\beta_z e^{i\omega t}]$

Question 3

Energies: $\frac{3}{2}\hbar\omega$, $\frac{5}{2}\hbar\omega$, $\frac{7}{2}\hbar\omega$

Vibrational degeneracy: 1, 3, 6

Degeneracy with spin factor: 2, 6, 12

Magic number: 2, 8, 20

Orbital angular momentum quantum number ℓ : 0, 1, 2 and 0

For the third level, analysis of the vibrational degeneracy equated to $2\ell + 1$ would also allow two $\ell = 1$ states for the third level. This is okay for the question, but actually ruled out by parity considerations.

Ground-state energy $\frac{\hbar\omega}{2} + \frac{3}{4}\lambda \left(\frac{\hbar}{m\omega}\right)^2$

Question 4 All spinors here have an implied subscript z .

(b) $\widehat{S}_+\beta = \hbar\alpha$; $\widehat{S}_-\alpha = \hbar\beta$; $\widehat{S}_+\alpha = 0$; $\widehat{S}_-\beta = 0$

(c) Maximum value for combined component quantum number $M_S=1$ and eigenstate $\alpha(1)\alpha(2)$. Successive application of S_- on this eigenstate produces two other eigenstates before a final operation produces a null result i.e. 0. Three eigenstates in total with spin quantum number $S = 1$.

(d) Separation $\gamma\hbar^2$.