Quantum Mechanics 1, solutions

Problem 1:
(B) This wave function is the ground-state wave function of the harmonic oscillator.

Problem 2:
(A) Symmetry! The average value of the potential energy is unchanged.

Problem 3:
(E) Postulates of Quantum Mechanics:
Any $\psi(\mathbf{r},t_0)$ can be expanded in terms of eigenfunctions,
$$\psi(\mathbf{r},t_0) = \sum_a c_a \psi_a(\mathbf{r}).$$
The probability that a measurement at $t = t_0$ will yield the eigenvalue a' is
$$P_{a'} = \frac{|c_{a'}|^2}{\sum_a |c_a|^2}.$$

Problem 4:
(A)

Problem 5:
(D) The magnetic dipole associated with the spin only experiences a force in an inhomogeneous magnetic field.

Problem 6:
(C) The magnetic dipole moment $\boldsymbol{\mu}$ of an atom is proportional to its angular momentum $\mathbf{J}$. The energy of a magnetic dipole in an external magnetic field is $E = -\boldsymbol{\mu}\cdot\mathbf{B}$. If B, for example, points into the z-direction, then $E = -\mu_z B$. Since μ_z is proportional to J_z, measurement of E will yield values proportional to m. For a given j, there are 2j + 1 possible values of m, from –j to +j in integer steps.

Problem 7:
(D) Transition c is the laser transition.

Problem 8:
(C) This is a scattering problem, not a bound-state problem. We have tunneling.

Problem 9:
(D) $\int_0^{2\pi} |A|^2 d\phi = 1$.

Problem 10:
(A)

Problem 11:
(D)

Problem 12:
(D) W is the work function of the metal.

Problem 13:
(D) Compton scattering: The quantity $h/(m_p c)$ is called the Compton wavelength for photon-proton scattering. The Compton wavelength is the amount by which the photon's wavelength changes when it scatters through 90°.

Problem 14:
(E) The total wave function is symmetric under exchange. The particles must be bosons.

Problem 15:
(D) In dipole transitions the spin is not involved.