Problem 1: (D)

Interpretation of the wave function

This is a 3D wave function.

$P_{100}(r) = |\psi_{100}(r)|^2 4\pi r^2 = (4/a_0^3)\, r^2 \exp(-2r/a_0)$. $dP_{100}(r)/dr = 0$.

Problem 2: (D)

Atomic spectra:

Problem 3: (D)

Quantization of angular momentum

The possible values that we can measure for the square of the magnitude of the orbital angular momentum are $L^2 = l(l+1)\hbar^2$. The possible projections we can measure along any axis, for example the z-axis are $L_z = m\hbar$. Here l is an integer, l = 0, 1, 2, ... , and for a given l, m can take on values from -l to l in integer steps.

Problem 4: (C)

Uncertainty principle

$\Delta\omega\Delta t \sim 1$.

Problem 5: (A)

The deBroglie relations

$\lambda = h/p$

Problem 6: (D)

Indistinguishable particles

Particles with half-integer spin obey Fermi-Dirac statistics, and are known as **fermions.** They are subject to the Pauli exclusion principle, which forbids them from sharing quantum states, and they are described in quantum theory by "antisymmetric states". Particles with integer spin, on the other hand, obey Bose-Einstein statistics, and are known as **bosons**. These particles can share quantum states, and are described using "symmetric states".

Problem 7: (B)

Probability density

The probability of finding the particle at time t in an interval Δx about the position x is proportional to $|\psi(x,t)|^2\Delta x$.

Problem 8: (D)

Normalization

$x\, x^* = |A|^2[(1+i)(1-i) + 4] = 1$, $|A|^2 = 1/6$

$P(S_z = -\frac{1}{2}\hbar) = 4|A|^2 = 2/3$

Problem 9: (E)

Pauli exclusion principle

n = 1, l = 0: m = 0, $m_s = 1/2, -1/2$. There are 2 possible electron states.

n = 1, l = 0: m = 0, $m_s = 1/2, -1/2$, there are 2 possible electron states.

or l = 1: m = -1, 0, 1, $m_s = 1/2, -1/2$, there are 3*2 = 6 possible states.

Problem 10: (C)
The Balmer series
$\lambda_\infty/\lambda_\alpha = (1/4 - 1/9)/(1/4) = 5/9$.

Problem 11: (C)
Energy levels of hydrogenic atoms.
$E_n = -mZ^2e^4/(2\hbar^2n^2)$

Problem 12: (C)
The harmonic oscillator: $E_n = (n + 1/2)\hbar\omega = (n + 1/2)hf$, $n = 0. 1, 2, \ldots$.

Problem 13: (C)
The harmonic oscillator: $E_n = (n + 1/2)\hbar\omega = (n + 1/2)hf$, $n = 0. 1, 2, \ldots$.

Problem 14: (C)
Bohr model of hydrogen atom
Angular momentum = $mr^2\omega = r_np = n\hbar$, $p = n\hbar/r_n$.

Problem 15: (A)
Square potentials
The wave function is continuous everywhere.