Problem 1: (E)
Orthogonality condition

Problem 2: (D)
Hydrogenic atoms
$E_I' = \mu' Z^2 e^4/(2\hbar^2) = E_I(\mu'/\mu)Z^2$.
$\mu' = m_1 m_2/(m_1 + m_2)$.

Problem 3: (B)
Boltzmann statistics
P(E) proportional to exp(-(E/kT))

Problem 4: (D)
Matrix multiplication

Problem 5: (D)
Step potentials

Problem 6: (D)
Hydrogenic atoms
For the hydrogen atom the photon energy is $(3/4)E_0$. To find the eigenfunctions and eigenvalues of the Hamiltonian of a hydrogenic atom we replace in the eigenfunctions of the Hamiltonian of the hydrogen atom a_0 by $a_0' = \hbar^2/(\mu' Z e^2) = a_0(\mu/\mu')(1/Z)$, and in the eigenvalues of the Hamiltonian of the hydrogen atom we replace E_I by $E_I' = \mu' Z^2 e^4/(2\hbar^2) = E_I(\mu'/\mu)Z^2$.
Here μ' denotes the reduced mass of the hydrogenic atom, $\mu' = m_1 m_2/(m_1 + m_2)$.

Problem 7: (A)
LS coupling
In the LS coupling scheme, a term is designated by ${}^{2S+1}L_J$.
2S+1 is called the **multiplicity** of the term.
$L = l_1+l_2+l_2+\ldots$ and $S = s_1+s_2+s_3+\ldots$, $J = L + S$.
Noble gases have only filled shells with L = S = 0.

Problem 8: (C)
The infinite square well

Problem 9: (C)
Energy and momentum operator
$p_x = (\hbar/i)\partial/\partial x$, $E = i\hbar\partial/\partial t$

Problem 10: (A)
The Pauli exclusion principle for fermions.

Problem 11: (E)

Compton scattering

$\Delta\lambda = (\lambda_f - \lambda_i) = [h/(m_e c)](1 - \cos\theta)$.

at 90^o: $1/(m_e c) = 1/p_f - 1/p_i$, $1/(m_e c^2) = 1/E_f - 1/E_i$.

Problem 12: (D)

The infinite square well

For large n we expect the classical result:

$$\overline{x^2} = \frac{1}{2a}\int_{-a}^{a} x^2 dx = \frac{1}{3}a^2$$

QM calculation (even functions, n = odd):

$$\langle x^2 \rangle = \frac{2}{2a}\int_{-a}^{+a} x^2 \cos^2\left(\frac{n\pi x}{2a}\right)dx = \frac{8a^2}{n^3\pi^3}\int_{-n\pi/2}^{+n\pi/2} y^2 \cos^2(y)dy \to \frac{a^2}{3} \text{ as } n \to \infty$$

Similarly for the odd functions (n = even).

Problem 13: (C)

Perturbation

The average shift of the bottom of the well (up or down) is zero.

Problem 14: (D)

Angular momentum

$L^2 = l(l + 1)\hbar^2$, $l = 3$.

Letters of the alphabet are associated with various values of l.

l = 0	s	l = 1	p	l = 2	d	l = 3	f	l = 4	g

Problem 15: (A)

Pauli exclusion principle