Modern Physics, solutions

Problem 1:
(C) Uncertainty principle: $\Delta E*\Delta t \sim \hbar$
Δt = lifetime of the excited state

Problem 2:
(A) Bohr atom: All other answers are incorrect.

Problem 3:
(B) Dimensions of atoms and nuclei: You should know typical atomic and nuclear dimensions.

Problem 4:
(B) The infinite well: Know the energy eigenfunctions and eigenvalues of the infinite well.

Problem 5:
(C) Hydrogen atom and hydrogenic atoms:
$E_n = -Z^2\mu e^4/(2\hbar^2 n^2)$, μ = reduced mass, E_n scales as $Z^2\mu$.

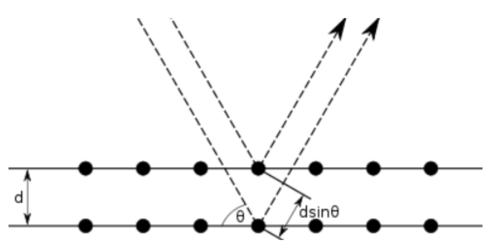
Problem 6:
(A) Hydrogen atom: $E_n = -E_I/n^2$, longest Lyman: $E_2 - E_1$, longest Balmer: $E_3 - E_2$, ratio: $(¼– 1)/(1/9 – ¼) = 27/5$. $\Delta E = hc/\lambda$. Wavelength ratio: 5/27

Problem 7:
(B) $KE = hf – \Phi = hc/\lambda – 2.28eV = 1.24*10^4 eV\text{-}Å/5000Å – 2.28eV = 0.2eV$

Problem 8:
(E) Interpretation of the wave function:
P = Integral $|\Psi(x)|^2dx$ from x = 2 to x = 4
$P = N^2(4 + 9)$
$1/N^2 = (1 +1 + 4 + 9 + 1)$
P = 13/16

Problem 9:
(C) The infinite well: The energy levels of the infinite well are proportional to n^2. The n = 2 wave function is shown.

Problem 10:
(D) Bragg reflection:
$2d\sin 30^o = \lambda = h/p = h/(mv)$



Problem 11:
(B) Operators:
In QM every observable is associated with its own operator.
For example: $p_x = (\hbar/i)\partial/\partial x$

Problem 12:
(B) The wave function: The wave function and its derivative must be continuous, the wave function must go to zero as x goes to infinity. The wave function oscillates in the classically allowed region and decays exponentially in the classically forbidden region.

Problem 13:
(B) The Pauli exclusion principle

Problem 14:
(C) The mean value of an observable: $\langle Q\rangle = \langle\Psi|Q|\Psi\rangle = \int_{-\infty}^{+\infty}\Psi^*Q\Psi dx$ in coordinate space in 1D.

Problem 15:
(D) The momentum operator: $(\hbar/i)\partial \exp(ikx)/\partial x = \hbar k \exp(ikx)$