Quantum Mechanics and Modern Physics on the GRE

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Relativity

Einstein's postulates
Length contraction, time dilation, relativistic momentum formulas
synchronization and simultaneity
Lorentz transformations
Relativistic Energy, $E^2 = (pc)^2 + (mc^2)^2$; photon has zero rest mass
Cherenkov radiation (particle moving faster than speed of light in that medium)

Early "Modern Physics"

de Broglie relation $\lambda=h/p$ The wave nature of matter
Blackbody radiation
 $I = \sigma T^4$ (Stefan-Boltzmann law); $\lambda_{max}T$ = constant (Wien's displacement law)
Photoelectric Effect
 formula, stopping potential, work function
 What does it demonstrate? (light has quantized energy)
Compton Scattering (know the formula: $\lambda' - \lambda = (h/mc)[1 - \cos\theta]$)
Bohr Model of the H-atom
 Energy = $-mZ^2e^4/8\varepsilon_0^2h^2n^2 \sim -13.6$ eV Z^2/n^2, Bohr radius
Franck-Hertz Expt. What does it demonstrate? (quantization of atomic states)
Bragg diffraction: $n\lambda = 2d\sin\theta$ ($n = 1, 2, 3, \ldots$)
Davisson-Germer Expt. demonstrated wave nature of electrons

Uncertainty Principle:

$\Delta E\, \Delta t > h/2$, $\Delta x\, \Delta p_x > h/2$

1D Schrod. Eq.

solutions and eigenenergies for the Harmonic oscillator potential ($E_n = \{n+1/2\}h\nu$), infinite square well ($E_n=n^2\pi^2\hbar^2/2ma^2$)
WF normalization
operators ($p = -i\hbar\partial/\partial x$), expectation values
Eigenfunctions and eigenvalues
Orthonormality, Kronecker delta
Perturbation theory, symmetry arguments
Sketching WFs for simple potentials (rules for curvature, continuity, asymptotic forms)
Scattering in 1D, barrier tunneling, reflection and transmission from a step potential

Atomic Physics

H-Atom WF including spherical harmonics and radial solutions
 Quantum numbers n, l, m. Symmetry of WFs
x-ray production (K, L, M, ...)

ground state electronic configurations, term notation
Symmetry and selection rules; s, p, d, electron WFs
Angular momentum operator **L**, commutation relations
J = **L** + **S**, Addition of angular momentum
Dipole selection rules (time dependent perturbation theory)
Spontaneous, stimulated emission; LASERs
Periodic table, closed shells, chemical bonding
Helium atom ground state wavefunction (WF)
H_2 molecule
Molecules: rotation, vibration, symmetry of WFs

Spin (Electron and nuclear):
What physical properties does it influence?
Stern-Gerlach experiment
Magnetic moment
Zeeman splitting
Spinors, spin eigenstates, addition of spin angular momenta
Spin-orbit coupling (fine structure)

Identical Particles:
Identical Fermions obey the Pauli exclusion principle
Bose-Einstein condensation
Symmetric vs antisymmetric WFs
Fermi energy, Fermi temperature

Radioactive Decay:
What particles are emitted?
Energy and momentum conservation

Nuclear Physics
Binding energy curve
radioactive decay

Particle Properties:
electron, proton, positron, neutron, muon, deuteron, alpha particle, beta particle, gamma ray, x-ray, neutrino, photon, phonon, fermion, boson, triton - Know what they are!
Conservation Laws (energy, momentum, charge, isospin, lepton number, baryon number, etc.)
Scattering Cross Section

Condensed Matter Physics
Hall Effect

Other useful skills:
Estimating numerical quantities quickly (order of magnitude estimates)

General Remarks:
Many of these problems are really very simple but are dressed up to look complicated