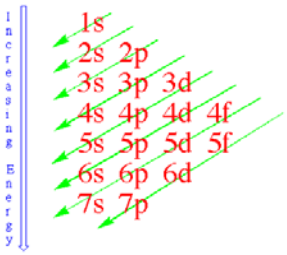
Solutions

Problem 1:
(C) Uncertainty principle
$\Delta E * \Delta t \sim \hbar$, $\Delta E \sim \hbar/\Delta t \sim (10^{-34}$ Js * 1eV/1.6*10^{-19} J)/(5*10^{-9}) = 2*10^{-7} eV

Problem 2:
(A) The periodic table
The electron subshells of atoms in their ground state are filled one electron at a time by putting each electron into the state with the lowest available energy. The energy ordering of the subshells can be remembered from the diagram below.



Problem 3:
(D) Energy stored in a capacitor, U = ½ Q^2/C
With the plates isolated, charge cannot be added or removed. An external force must do work to remove the dielectric.

Problem 4:
(A) The Lorentz force
$\mathbf{F} = q\mathbf{v}\times\mathbf{B} = 0$.

Problem 5:
(B) Thin lenses
$1/x_i = 1/f - 1/x_o = 1/4 - 1/3 = -1/12$, $x_i = -12$, $M = - x_i/x_o = 12/3 = 4$.

Problem 6:
(C) The 1D Harmonic oscillator in QM

Problem 7:
(B) Energy conservation
$[1/(4\pi\varepsilon_0)]q_1q_2/(x^2 + y^2)^{½} = ½ mv^2$.
In SI units: 9*10^9*10^{-11}/(5*10^{-2}) = ½*10^{-3}*v^2.

Problem 8:
(D) Terminal speed: $F_{total} = 0$
$mg = \beta v$.

Problem 9:
(B) Power, P = dE/dt
dE/dt = mv dv/dt, dv/dt is proportional to 1/v neglecting friction and drag.

Problem 10:
(D) Angular momentum
$L = I\omega$, $I = \frac{1}{2}Mr^2 + MR^2$.

Problem 11:
(A) Conservation of angular momentum

Problem 12:
(C) Spin ½ particles

Problem 13:
(A) Bernoulli's equation
$P_1 + \rho g h_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho g h_2 + \frac{1}{2}\rho v_2^2$

Problem 14:
(D) Rayleigh scattering

Problem 15:
(E) Multiple "slit" interference
$d\sin\theta = n\lambda = nc/f = n*3*10^8/10^6$ m = n*300 m, d/2 = n*300 m.

Problem 16:
(B) Harmonic motion, a mass on a spring
For a single mass m on a massless spring with spring constant k we have $\omega = (k/m)^{1/2}$.

Problem 17:
(B) Lagrangian mechanics, cyclic coordinates
If q_i is a cyclic coordinate then $dp_i/dt = 0$. (Lagrangian formalism: $\partial L/\partial(dq_i/dt) = p_i$)

Problem 18:
(D) Relativistic energy and momentum
$pc = \gamma mvc = 5$ MeV; $E = \gamma mc^2 = 10$ MeV; $pc/E = v/c = \frac{1}{2}$

Problem 19:
(C) Entropy
A reversible process does not change the entropy of the system.

Problem 20:
(E) Linear polarizers
$I_t = I_0\cos^2\theta$, (Law of Malus) for a single polarizer