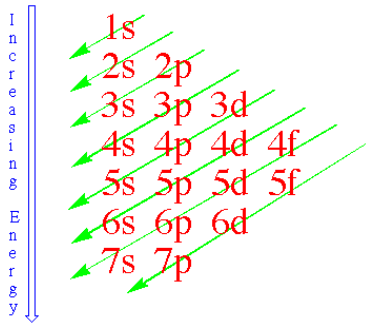
Problem 1: (C)
Uncertainty principle
$\Delta E^*\Delta t \sim \hbar$, $\Delta E \sim \hbar/\Delta t \sim (10^{-34}$ Js * 1eV/1.6*10^{-19} J)/(5*10^{-9}) = 2*10^{-7} eV

Problem 2: (A)
The 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
F = q**v**×**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

$$\frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{\sqrt{x^2+y^2}} = \frac{1}{2}mv^2$$

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 = βv.

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: (A)
The hydrogen atom

Problem 13: (C)
Spin ½ particles

Problem 14: (A)
Bernoulli's theorem

$$\frac{1}{2}\rho v_1^2 + P_1 + \rho g h_1 = \frac{1}{2}\rho v_2^2 + P_2 + \rho g h_2$$

Problem 15: (D)
Rayleigh scattering

Problem 16: (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 17: (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 18: (B)
Lagrangian mechanics, cyclic coordinates

If q_n is a cyclic coordinate then $dp_n/dt = 0$. (Lagrangian formalism: $p_n = \frac{\partial L}{\partial \dot{q}_n}$).

Problem 19: (D)
Relativistic energy and momentum
$pc = \gamma mvc = 5$ MeV; $E = \gamma mc^2 = 10$ MeV; $pc/E = v/c = ½$

Problem 20: (D)
The electric potential, the principle of superposition
$V = k \int_0^l \lambda\, dx/(2l-x) = (kQ/l) \int_0^l dx/(2l-x) = (kQ/l) \int_l^{2l} dx'/x' = (kQ/l)\ln 2$

Problem 21: (C)
Entropy
A reversible process does not change the entropy of the system.

Problem 22: (E)
Linear polarizers
$I_t = I_0 \cos^2\theta$, (Law of Malus) for a single polarizer

Problem 23: (D)
Commutator algebra, commutation rules for angular momentum
$[J_x J_y, J_x] = J_x [J_y, J_x] + [J_x, J_x] J_y = -i\hbar J_x J_z$

Problem 24: (B)
Momentum conservation
$$4m\sqrt{2gh} - m\sqrt{2g \cdot 4h} = 5mv\,, \quad v = \frac{2}{5}\sqrt{2gh}$$

Problem 25: (D)
Rotational kinetic energy, $T_{rot} = \frac{1}{2} I\omega^2$.
$\Delta T_{rot} = 2(80^2 - 40^2)J = 9600$ J