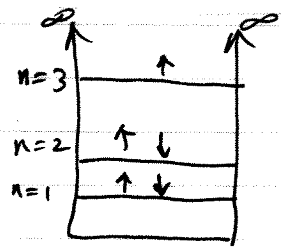
Solutions to homework due Mar 7, 2005

36. The energy levels of the infinite square well of width L are

$$E_n = h^2n^2/8mL^2.$$

An electron in the well has two quantum numbers: n and $m_s = \pm\frac{1}{2}$. To be consistent with the Pauli exclusion principle, a maximum of two electrons can be in each level. The lowest energy state will have two electrons in the $n = 1$ state, two electrons in the $n = 2$ state, and one electron in the $n = 3$ state. The total energy is

$$E = 2E_1 + 2E_2 + E_3 = 2(h^21^2/8mL^2) + 2(h^22^2/8mL^2) + (h^23^2/8mL^2) = \boxed{19h^2/8mL^2.}$$



38. The shortest wavelength X-ray has the most energy, which is the maximum kinetic energy of the electron in the tube:

$$E = (1.24 \times 10^3\ \text{eV}\cdot\text{nm})/\lambda = (1.24 \times 10^3\ \text{eV}\cdot\text{nm})/(0.029\ \text{nm}) = 4.3 \times 10^4\ \text{eV} = 43\ \text{keV}.$$

Thus the operating voltage of the tube is $\boxed{43\ \text{kV.}}$

The answer is a voltage, not an energy in eV.

42. If we assume that the shielding is provided by the remaining $n = 1$ electron, we use the energies of the hydrogen atom with Z replaced by Z – 1. The energy of the photon is

$$hf = \Delta E = -(13.6\ \text{eV})(42 - 1)^2[(1/3^2) - (1/1^2)] \doteq 2.03 \times 10^4\ \text{eV}.$$

The wavelength of the photon is

$$\lambda = (1.24 \times 10^3\ \text{eV}\cdot\text{nm})/\Delta E = (1.24 \times 10^3\ \text{eV}\cdot\text{nm})/(2.03 \times 10^4\ \text{eV}) = \boxed{0.061\ \text{nm.}}$$

We do not expect perfect agreement because there is some $\boxed{\text{partial shielding provided by the } n = 2 \text{ shell,}}$ which was ignored when we replaced Z by Z – 1.