# Exam 2 --- 2003 --- SOLUTIONS

I. Multiple choice

1.e., 2.d., 3.a., 4.c., 5.c.

II. a. $k^2 = 2mE/\mathbf{h'}^2$, $k=8.0\text{x}10^9 m^{-1}$ (**h'** is meant to be h-bar)
$\lambda=7.9\text{x}10^{-10}$m .
b. $\alpha$=Square root(2m|V-E|)/**h'** $=1.6\text{x}10^9 m^{-1}$.
c. Yes, there is reflection. The stationary solution that is written for the wave on the left must be a superposition of right-going and left-going waves. The solution for x>0 shows a diminishing probability density, but the probability must sum to 1 everywhere, so part of the probability density on the left must come from the reflected wave. Other points of view involving the probability of finding the electron in the forbidden region vs. outside were sensible too.

III. a. Take the 2nd derivative of the wavefunction $\psi$ with respect to x and obtain $-k_1^2\psi$. The 2nd derivative with respect to y gives $-k_2^2\psi$. So putting these together gives $-(\mathbf{h'}^2/2m)(k_1^2+k_2^2)\psi = E\,\psi$.
The $\psi$ is a common factor , leaving $-(\mathbf{h'}^2/2m)(k_1^2+k_2^2) = E$.
b. At x=L or y=L the wavefunction must vanish. So $k_1L=n_1\pi$ and $k_2L=n_2\pi$. Hence $k_1=n_1\pi/L$ and $k_2=n_2\pi/L$ .
c. $E_{n1,n2}=(h^2/8mL^2)(n_1^2 + n_2^2)$
Lowest energy state has $n_{1\text{ or }2}=1$. Hence $E_{1,1}= (h^2/4mL^2)$
d. 2 electrons can occupy the lowest energy state. The 3rd electron must go to the next highest level (2,1 or 1,2), giving $2\text{x}(h^2/4mL^2)+5(h^2/8mL^2) = 9(h^2/8mL^2)$.
e. Bosons can all occupy th same energy state, so 3 $E_{1,1}= (3h^2/4mL^2)$.

IV. a. $1s^22s^22p^1$
b. $-Z^2E_0/n^2$ = 25x13.6/4 eV = 85.0 eV
c. $-Z_{screen}^2E_0/4=8.28$, so $Z_{screen}=1.56$
d. l=1, so $\mu$=square root (2) $\mu_B$
e. 4f -> 3d -> 2p so E(4f)-E(3d)=$-Z_{screen}^2E_0/16 + -Z_{screen}^2E_0/9$ = 1.61 eV
E(3d)-E(2p)= $-Z_{screen}^2E_0/9 + -Z_{screen}^2E_0/4$ = 4.6 eV

V. a. $p_{E1}=Qr=1.60\text{x}10^{-19}$Coul x $2.36\text{x}10^{-10}$m$=3.78\text{x}10^{-29}$Coul m
b. measured dipole / theoretical dipole = 3.00/3.78 = 0.79 or 79%.