1. (a) Explain the Bohr's two assumptions and use these assumption to derive the total energy of an electron:

$E_n = -\frac{mZ^2e^4}{(4\pi\varepsilon_0)^2 2\hbar^2 n^2}$ n = 1,2, 3,...(15%) (b) What is the Planck's postulate and use the formula $\langle\varepsilon\rangle = \frac{\sum_0^\infty \varepsilon P(\varepsilon)}{\sum_0^\infty P(\varepsilon)}$ to derive Planck's expression for the average energy $<\varepsilon>$ and also his blackbody spectrum. Where $P(\varepsilon) = \frac{e^{-\varepsilon/kT}}{kT}$. (15%)

2. Determine Planck's constant h from the fact that the minimum x-ray wavelength produced by 40 keV electrons is 3.11×10^{-11}m. (e: 1.6×10^{-19} coulomb, c: 3×10^{8}m) (10%)

3. Find the possible values of the total spin s', the total orbital angular momentum ℓ', and the total (spin + orbital) angular momentum j' for a configuration with three optically active electrons of quantum numbers $\ell_1 = 1, \ell_2 = 2$, and $\ell_3 = 4$. (10%)

4. (a) The infinite square well and the two lowest states, one wave function with the lowest state is sketched as the figure 1. Please sketch the second wave function. A finite square well with two energy states is shown in figure 2 and sketch two corresponding graphs of the two wave functions. (10%) (b) A potential well with a step is shown in figure 3 and draws the wave function for fifth energy level in this "step well". (10%)

5. (a) Verify that the wave function

$$\Psi(x,t) = \begin{cases} A\sin\frac{2\pi x}{a}e^{-iEt/\hbar} & -a/2 < x < +a/2 \\ 0 & x < -a/2 \text{ or } x > +a/2 \end{cases}$$

is a solution to the Schroedinger equation in the region $-a/2 < x < +a/2$ for a particle which moves freely through the region but which is strictly confined to it. (6%) (b) Also determine the value of the total energy E of the particle in this first excited state of the system. (6%) (c) Normalize the wave function, by adjusting the value of the multiplicative constant A so that the total probability of finding the associated particle somewhere in the region of length a equals one. (6%) (d) Calculate the expectation value of x and x^2 for the particle associated with the wave function. (6%) (e) Calculate the expectation value of p and p^2 for the particle associated with the wave function. (6%)

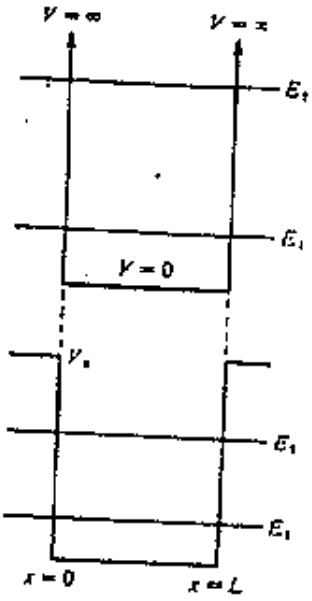

Fig. 1. (Top)

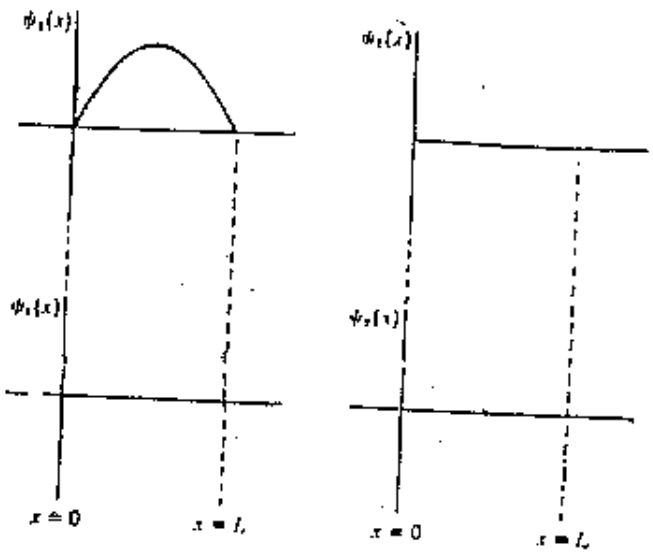

Fig. 2. (Bottom)