Advanced Physical Chemistry

(1) Explain the following terms: (20%)

(a) Micelles and Hydrophobic interactions

(b) Fluorescence and Phosphorescence

(2) Give the derivation and state the reasoning for the Boltzmann distribution law. (15%)

(3) The eigenfunction for a 1s electron of a hydrogen atom is given by

$\Psi = N\, e^{-r/a_o}$, where a_0 is the radius of the first Bohr orbit for hydrogen, and

N is the nornalization constant.

(a) Show that the radius at which there is a maximum probability of finding a 1s electron (in any direction) is just $r_{max} = a_o$. (10%)

(b) Derive the normalization constant (N) and calculate the mean distance $\langle r_{1s} \rangle$ between the nucleus and 1s electron. (assume that $a_0 = 52.9$ pm). (15%)

Note: $\int_0^\infty x^n e^{-ax}\, dx = n!/a^{n+1}$

(4) Sketch and then tell the first three diffraction planes for the fcc and bcc lattice. How can you tell a molecular crystal whether it has fcc or bcc structure ? (10%)

(5) Two blocks of the same metal are of the same size but are at different temperatures, T_1 and T_2. These blocks of metal are brought together and allowed to come to the same temperature.

(a) Express the entropy change in terms of Cp, T_1 and T_2. (10%)

(b) Show that the entropy change in the problem above is spontaneous and in aggrement with the second law of thermodynamics. (10%)

(6) For the reaction $H_2O \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} H^+ + OH^-$, the relaxation time, τ (sec) may be written as

$$\tau = \frac{1}{k_1 + k_{-1}([H^+] + [OH^-])}$$

If τ is 3.6×10^{-6} sec, what are the values of k_1 and k_{-1}? (10%)