1). Electrons are accelerated by a 1000 V potential drop. (a) Calculate the de Broglie wavelength. (b) Calculate the wavelength of the X-rays that could be produced when these electrons strike a solid. (16%)

2). Calculate the lowest possible energy for an electron confined in a cube of sides equal to (a) 1.0×10^{-11} m, and (b) 1 fm (1 femtometer $=10^{-15}$ m). The latter cube is the order of magnitude of an atomic nucleus, what do you conclude from the energy you calculate about the probability of a free electron being present in a nucleus? (16%)

3). Suppose the density of a binary solution is known as a function of mole fraction composition. (a) Show that the partial molar volume of component 1 will be given by the expression

$$\bar{V}_1 = [\rho M_1 - X_2(X_1M_1 + X_2M_2)(\partial\rho/\partial X_1)_{T,p}]/\rho^2$$

where M_1 and M_2 denote molecular weights. (b) The density of methanol (1) and water (2) mixtures at 25°C is

$$\rho(g/ml) = 0.9971 - 0.18527X_1 + 0.22013X_1^2 - 0.60418X_1^3 + 0.53912X_1^4 - 0.18012X_1^5$$

Calculate the partial molar volume of methanol at $X_1 = 0.5$. (18%)

4). An imidazole buffer of pH 7 containing 0.05 mole L^{-1} imidazole has a relaxation time of 2.9×10^{-9} s at 25°C, what are the values of the rate constants for the reaction $C_3N_2H_4 + H^+ \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} C_3N_2H_5^+$

The pK for the imidazole at this temperature is 7.21. (17%)

5). The measured density of an equilibrium mixture of N_2O_4 and NO_2 at 15°C and 1.013 bar is 3.62 gL^{-1}, and the density at 75°C and 1.013 bar is 1.84 gL^{-1}. What is the enthalpy change of the reaction $N_2O_4(g) = 2NO_2(g)$? (17%)

6). The electromotive force of the cell, $Cd|CdCl_2{\cdot}2\frac{1}{2}H_2O$; sat. solution$|AgCl|Ag$, at 25°C is 0.67533 V, and the temperature coefficient is -6.5×10^{-4} VK^{-1}. Calculate the value of ΔG, ΔS, and ΔH at 25°C for the reaction

$$Cd(cr) + 2AgCl(cr) = 2Ag(cr) + CdCl_2{\cdot}2\tfrac{1}{2}H_2O(cr)$$ (16%)

121

Note: mass of electron $m = 9.110\times10^{-31}$ kg
charge " " $e = 1.602\times10^{-19}$ C
Planck constant $h = 6.626\times10^{-34}$ J·s.