a. Assuming that release of the drug is far from equilibrium, calculate the initial rate of drug release from the particles in units of moles of drug per hour (mol h^{-1}) from the information given.

b. If the absorbance of the solution after the system reached equilibrium in 72 hours was 1.163, calculate the ratio of drug remaining in the nanoparticle to that that which is free in solution.

3 Apoferritin is being considered as a potential delivery vehicle for drugs. Consider a solution which contains the apoferritin monomer, 2.4×10^{-4} *M*, and a drug, 30 m*M*, which is originally at pH 2.0. When the pH of the solution is raised to 7.4, the individual monomeric subunits associate to form intact apoferririn, which contains 24 subunits in a shell-like structure. If the internal diameter of the apoferritin shell is 8 nm, it is approximately spherical in structure, and there is no active 'recruitment' of drug molecules to the inside of the apoferritin shell when it forms, calculate the approximate average number of drug molecules that would be trapped inside intact apoferritin. The volume of a sphere is $V = 4/3\pi r^3$.

4 The longitudinal relaxation rate constant, r_1, at 40 °C, 60 MHz, of a new Ga^{3+} contrast agent was obtained using $(T_{1(obs)})^{-1} = (T_{1(diam)})^{-1} + r_1[Gd^{3+}]$, where $T_{1(obs)}$ and $T_{1(diam)}$ are the relaxation time constants of the sample and the matrix in seconds and $[Gd^{3+}]$ is the concentration of Gd in m*M*. Calculate $T_{1(obs)}$ if $[Gd^{3+}] = 0.044$ m*M*, $r_1 = 173$ mM^{-1} s^{-1} and $(T_{1(diam)})^{-1} = 0.25$ s^{-1}.

5 The crystal structure of a gold nanoparticle with bound *p*-mercaptobenzoic acid (*p*-MBA) molecules with the formula $Au_{102}(p\text{-}MBA)_{44}$ has been published [see Jadzinsky, P.D., Calero, G., Ackerson, C.J., *et al.* (2007) Structure of a thiol monolayer-protected gold nanoparticle at 1.1 Å resolution. *Science*, **318**, 430–433]. The authors of the paper suggested that the reason the cluster is stable is that 44 gold atoms of the cluster contribute their 6*s* electrons to bonding the 44 *p*-MBA ligands to the cluster, and the remaining 58 Au^0 atoms contribute one electron each to a 'shell,' associated with the entire cluster, that can hold a total of 58 electrons. This accounts for the total of 102, 6*s*, electrons that are associated with the Au^0 atoms in the cluster. If 44 Au atoms react with 44 thiols to form 44 two-electron Au–S bonds, write a balanced chemical reaction for what may be taking place when thiols are attached to the gold surface. The electronic configuration of Au^0 is $[Xe]4f^{14}5d^{10}6s^1$.

6 Calculate the number of gold atoms in a spherical gold nanoparticle with a diameter of 26 nm ($d = 26$ nm). The density of gold is 19.3 g cm^{-3}.

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