Biological Chemistry I

I Here is a description of protein motions in solution. Answer the following questions below:

Two kinds of protein molecules (X and Y) with spherical shape encounters and thereby form a protein complex (XY). Because both proteins repeatedly collide with the surrounding water molecules, the proteins move while frequently changing their speed and direction of motions. This random motion causes [i] of proteins, and [ii] is a good measure of the particle mobility. The number of the collisions between X and Y per unit time is given by,

$$A = 4\pi R_{XY}(D_X + D_Y)N_A \qquad \text{(Eq. 1)}$$

where R_{XY} is the inter-particle distance between X and Y within the XY complex, and N_A is Avogadro's number. D_X (or D_Y) represents the [ii] of protein X (or Y). The A value in Eq.1 corresponds to the Arrhenius pre-exponential factor. For a given reaction with zero activation energy, the rate of formation of the XY complex only depends on [iii]. These reactions are known as [iv] providing us [v] bound of the reaction rate constants in solution.

(1) Using the choices given below, fill in the blanks ([i] ~ [v]) with the most appropriate words.

upper	lower	absolute temperature
hydrophobic interaction	activation free energy	collision frequency
diffusion	electrostatic interaction	activation entropy
tyndall phenomenon	parallel reaction	diffusion coefficient
diffusion-limited reaction	steady state	consecutive reaction

(2) D_X and D_Y are related to the particle radii of X (R_X) and Y (R_Y), respectively, according to the following Stokes-Einstein equations.

$$D_X = \frac{k_B T}{6\pi\eta R_X} \qquad D_Y = \frac{k_B T}{6\pi\eta R_Y} \qquad \text{(Eq. 2)}$$

where k_B is the Boltzmann constant, T is absolute temperature, and η is solvent viscosity (0.83×10^{-3} Pa s). Calculate the A value at 300 K using Eq. 1, Eq. 2, and the approximation for $N_A k_B \approx 8.3 \times 10^3$ Pa L K^{-1} mol^{-1}.

(3) The rate of formation of a complex by existing protein molecules is lower than the prediction of Eq.1. What is the major reason for this discrepancy?

Biological Chemistry II

II Answer the following questions.

(1) Ubiquitin contains the amino acid sequence IENVKAKIQDKE.

① Which of the amino acid residues would have:

(i) positivelly charged side chain under neutral pH conditions, and

(ii) hydrophobic side chain with an asymmetric carbon?

For those that would, write the three-letter code and draw the structural formula of the side chain.

② The pitch of α-helix (the vertical distance between one consecutive turn of the helix) is 0.54 nm. What is the approximate length in the axial direction of the α-helix formed by this amino acid sequence?

③ Explain the biological function(s) of ubiquitin.

(2) It has been argued that three-dimensional structures of proteins in their native states are not static but fluctuating. What is the experimental evidence supporting this claim?

(3) Sodium dodecyl sulfate (SDS; $NaC_{12}H_{25}SO_4$) forms micelles above a certain concentration (termed critical micelle concentration).

① Explain a method to measure the critical micelle concentration of SDS.

② Explain the experimental method to estimate the number of dodecyl sulfate ions in one micelle.

③ Molecular weights of proteins can be estimated based on their electrophoretic mobilities in polyacrylamide gels after SDS treatment. Explain the principle of this technique referring the effect of the SDS treatment.