Rumi De
18/09/18

Question Paper for Mid Semester examination

Biological Physics; Instructor: Dr. Rumi De; Date 18.09.2018; Total Marks: 20

---

1. (a) Show that, for a 'Freely Jointed Chain' polymer in **2D**, the mean square average of 'end-to-end' distance is, $\langle R^2 \rangle = mb^2$, where m is the number of segments of the polymer chain and b is the length of each segment. **2**

(b) Write the diffusion equation of migrating particles in the presence of an external potential V(x) and at temperature T. (i) Illustrate graphically how the particles initially located at X_0 at time **t=0** spread out in space at two different times t_1 and t_2. (ii) Compare it (graphically) how the particles will diffuse along **X** with time **t** in the absence of potential V(x). **2**

(c) A polymer chain with fluorescent tag on one end and its quencher (another dye) on the other end is dissolved in a non-interacting solvent. The fluorescence is quenched when the quencher is in very close proximity. If there is no specific interaction between the two ends other than the fluorescence quenching, how does the fluorescence intensity change with the chain length?
[Quenching refers to a process which decreases the fluorescence intensity of a given substance.] **2**

2. The Van der Waals interaction energy between two point particles separated by a distance 'r' has the power law form, $V(r) = -\frac{C}{r^n}$; where C and n (n>3) are constants. Show that for a point particle, a distance 'R' away from a semi-infinite flat surface, the total interaction energy (sum of the interaction energy of all particles), will be given by,

$$V(R) \sim \frac{C}{(n-2)(n-3)R^{n-3}}. \qquad \mathbf{5}$$

3. (a) Derive Einstein's relation, $D\gamma = K_B T$; where D is diffusion constant, γ denotes viscous friction, K_B Boltzmann constant and T is the temperature.

(b) Consider a solution containing charge particles (say, salt water solution) under an electric field E. Show that the electrical resistance of the solution reflects frictional dissipation.

2+2=4

4. (a) Show that the excluded volume interaction between molecules leads to an effective repulsion.

(b) Modeling by Flory's theory, show that in **3D**, the size of a polymer chain, **R**, scales with $N^{3/5}$, where **N** is the no of monomers (or the no of independent segments of the chain).

2+3=5

[Given, $P(R,N) = (3/2\pi nN)^{3/2} e^{-3R^2/2Na^2}$, where 'N' is the number of segments of a polymer chain and 'a' is the length of each segment.]