BBL342: Physical and Chemical Properties of Biomolecules

Quiz I

Total: 10 Marks; 20 minutes 28.01.2023

1. Ionic interactions are stronger in water than in vacuum because water forms strong hydrogen bonds with polar molecules. True/False (1)
   Logic: Water stabilizes the ions by hydration which reduces the ion-ion interactions

2. When two atoms approach each other closely, the energy goes up because (1)
   a. the nuclei of the atoms repel each other
   b. the electrons induce transient dipoles on each atom
   c. the electron clouds on each atom repel each other
   d. all of the above

3. At pH = 7.0, there are how many free protons in an E. coli cell (assume $V_{E.coli} = 1\ \mu m^3$) (1)
   a. 10^7
   b. 6
   c. 60
   d. none of the above

4. The rate constant for an elementary reaction is $10^{-3}M^{-1}s^{-1}$. The order of the reaction is (1)
   a. Zero
   b. First
   c. Second
   d. None of the above

5. The force arising from a noncovalent interaction between two approximately spherical molecules at the energy minimum is always (1)
   a. maximum
   b. minimum
   c. zero
   d. infinity

6. Previously we assumed that *E. coli* cells have the same density as water. However, a more reasonable estimate is that the density of the macromolecules of the cell is 1.3 times that of water. Using that two-thirds of the mass is water and that the remaining one-third is macromolecular, compute the percentage error made by treating the macromolecular density as the same as that of water. (2)

   If an E.coli cell has volume V, then previously estimated mass of E.coli, $M_0 = \rho_w V$.

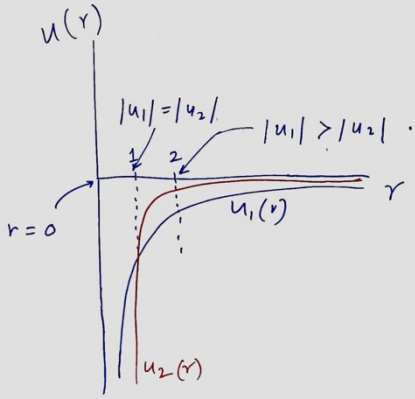
   According to the mass ratio, mass of water = $\frac{2}{3}\rho_w V$ and macromolecular mass = $\frac{1}{3}\rho_w V$.

   Newly estimated macromolecular mass = $\frac{1.3}{3}\rho_w V$.

   So, the newly estimated total E.coli mass becomes $M_1 = \frac{2}{3}\rho_w V + \frac{1.3}{3}\rho_w V = \frac{3.3}{3}\rho_w V = 1.1M_0$.

   So, the percentage error made by treating the macromolecular density as the same as that of water = $\frac{M_1 - M_0}{M_1} \times 100 = \frac{0.1}{1.1} \times 100 \approx 9$. I have given credit for going in the right direction or deducted marks if steps were not shown.

7. You have two different pair potential functions: $u_1(r) = -\frac{1}{r}$, $u_2(r) = -\frac{1}{r6}$
   (a) Plot both functions.
   (b) At *r* = 1, which pair potential has the stronger attraction?
   (c) At *r* = 2, which pair potential has the stronger attraction? (3)



I have also given credit for an alternative approach in terms of force

$$f(r) = -\frac{du}{dr}$$

$$f_1(r) = \frac{1}{r^2}$$

$$f_2(r) = \frac{6}{r^7}$$

$f_1(1) = 1$
$f_2(1) = 6$ $\Rightarrow f_2(1) > f_1(1)$ u_2 stronger

$f_1(2) = \frac{1}{4}$
$f_2(2) = \frac{6}{2^7}$ $\Rightarrow f_1(2) > f_2(2)$ u_1 stronger