Biophysics exam row 1. Answer the questions on your own paper. Solve also the MCQ question, on the extra paper. Read all questions and answer them in the order you prefer. All dots in numbers are the equivalent to dots in computer science. Example: $4.31 = \frac{431}{100}$

Name (make sure I can easily read it): ______________________________

1. (2 points) A person weighing 100kg has a basal metabolic rate of $2400\frac{kcal}{day}$. The person has just got ill from a viral infection and during a time interval of one hour his body temperature raised from 37^{o}C to 39^{o}C. Find out the percentage increase of this person's metabolic rate **during** the one hour time interval when his body temperature went from 37^{o}C to 39^{o}C. One calorie is 4.186J. The water specific heat, the approximation to be used for the body specific heat, is $4186\frac{J}{Kg\cdot K}$.

   - The mass of the person is $m = 100kg$
   - The temperature increase is $\Delta T = 2^oC$
   - The body specific heat is $c = 4186\frac{J}{Kg\cdot K}$

   The heat needed to warm up the person in one hour is $mc\Delta T$. The basal metabolic rate is $M_b = 100\frac{kcal}{h}$. The percentage increase in metabolic rate is $100\frac{mc\Delta T}{4.186\cdot 100\cdot 1000} = 100\frac{100\cdot 4186\cdot 2}{4.186\cdot 100\cdot 1000} = 200\%$

2. (2 points) The total energy of a biomembrane is given by the Helfrich-Canhan hamiltonian $H = \int[\sigma + 2kH^2 + k_sK]dA$, where H and K are curvatures, defined as $\frac{1}{R}$, with R being a radius, while dA is a membrane area element. k is the bending modulus and k_s is the splay modulus. Indicate the correct units for the bending modulus k.

   - ◯ Newtons N
   - ◯ Newtons times square meters Nm^2
   - ◯ Joules
   - ◯ Joules per square meters $\frac{J}{m^2}$
   - ◯ Joules times square meters Jm^2

   $[\sigma + 2kH^2 + k_sK]dA$ is an energy, thererfore $2kH^2dA$ has units of energy. We know that H^2 has units of m^{-2} and dA has units of m^2, m meters. Therefore k is an energy measured in Joules.

3. (1 point) After they have influenced the receptors in the post-synaptic membrane, those neurotransmitter molecules which are not broken down by enzymes diffuse back to the pre-synaptic membrane, which lies $2\cdot 10^{-8}m$ away, with a diffusion coefficient which has been determined to be $5\cdot 10^{-6}cm^2s^{-1}$. How long does it take the molecules to make this short journey? The length that the neurotransmitters have to diffuse is $L = 2\cdot 10^{-8}m$.
   In three dimensions:

   $$< L^2 >= 6Dt \tag{1}$$

   which means that the time needed for the journey is:

   $$t = \frac{L^2}{6D} \tag{2}$$

   Substituting the numbers we get the time in seconds:

   $$t = \frac{4\cdot 10^{-16}}{6\cdot 5\cdot 10^{-6}cm} = \frac{4\cdot 10^{-16}}{6\cdot 5\cdot 10^{-10}} = \frac{2}{15}10^{-6} = 0.13\mu s \tag{3}$$

4. (1 point) Consider a diagnostic ultrasound of frequency $5.00MHz$ that is used to examine an irregularity in soft tissue. If the speed of sound in tissue is $1800\frac{m}{s}$, what is the wavelength of this wave in tissue? The wavelength is the speed of sound multiplied by the period of the wave, or the speed of sound divided by the frequency: $\lambda = \frac{v}{f} = \frac{1800}{5\cdot 10^6} = 360\mu m$

5. (1 point) A far sighted person sees that her contact lens prescription is 2.00 D. What is her near point? The length of eye lens to retina is 2cm. The near point for ideal vision is 25cm.
The far sigted person will have a maximum power of the eye inferior to the maximum power of the eye for the ideal vision. Terefore, her far point will be farther away than the far point of a person with ideal vision. P_{ce} is the power of the corrected eye, corresponding to the ideal vision. $P_l = 2$ is the power of the lens. P_e is the power of the uncorrected eye

$$P_{ce} = P_e + P_l \tag{4}$$

$$P_{ce} = P_e + P_l = 100(\frac{1}{2} + \frac{1}{25}) = 100\frac{27}{50} = 54 \tag{5}$$

Inserting 5 into 4 we have for the uncorrected eye:

$$P_e = 54 - 2 = 52D \tag{6}$$

But

$$P_e = \frac{1}{x_i} + \frac{1}{x_{fp}} \Rightarrow \frac{1}{x_{fp}} = 52 - 50 = 2 \Rightarrow x_{fp} = \frac{1}{2}m = 50cm \tag{7}$$

Where x_{fp} is the far point we are looking for.

6. (1 point) To kill the HIV virus, heat treatments with different temperature T and holding time t are used. We know that the bond to be broken during these heat treatments has a value of $\Delta E = 84.5k_B T_{room}$ where $T_{room} = 300K$. Treatment B has a holding time of 72h at 80^{o}C. A new proposed treatment at 78^{o}C is treatment D. What is the holding time needed at 78^{o}C so that the treatment D will have the same efficacy as treatment B?

$$n_{Bjumps} = \nu_{atom} t_B e^{-\frac{\Delta E}{k_B T_B}} \tag{8}$$

$$n_{Djumps} = \nu_{atom} t_D e^{-\frac{\Delta E}{k_B T_D}} \tag{9}$$

If treatment D will have the same efficacy as treatment B, then $n_{Bjumps} = n_{Djumps}$ which means that:

$$\nu_{atom} t_B e^{-\frac{\Delta E}{k_B T_B}} = \nu_{atom} t_D e^{-\frac{\Delta E}{k_B T_D}} \tag{10}$$

giving for t_D

$$t_D = t_B e^{-\frac{\Delta E}{k_B T_B}} e^{\frac{\Delta E}{k_B T_D}} = t_B e^{\frac{84.5 k_B T_{room}}{k_B}\left(\frac{1}{T_D} - \frac{1}{T_B}\right)} = t_B e^{\frac{84.5 T_{room}(T_B - T_D)}{T_D T_B}} = 72 e^{\frac{84.5 \cdot 300 \cdot 2}{353.15 \cdot 351.15}} = 72 * 1,5 = 108h \tag{11}$$