

Name:

Date:

**Partial Exam**

**Biophysics**  
*Bioinformatics degree*

1) (2.0 points) Two synaptic vesicles have a volume of  $20.000 \text{ nm}^3$  and  $30.000 \text{ nm}^3$ , respectively. In the small vesicle, there are  $2 \cdot 10^6$  molecules of a neurotransmitter. In the big vesicle, there are only  $10^6$  molecules of the same neurotransmitter.

a) Considering a division of the volume of the synaptic vesicles in cubic cells of  $1 \text{ nm}^3$ , calculate the entropy associated with the movement of this neurotransmitter in both vesicles.

b) Then, consider a fusion of both vesicles forming a vesicle of  $50.000 \text{ nm}^3$  of volume. Calculate the entropy associated with the movement of all  $3 \cdot 10^6$  molecules of the neurotransmitter in this new generated vesicle. Compare with the sum of the previous entropies and discuss if this process is reversible or irreversible, and if this process is related with some thermodynamic law.

2) (1.5 points) A container of 0.5 litres has  $4 \cdot 10^{20}$  molecules of  $\text{CO}_2$  at  $25^\circ\text{C}$ . Another container of  $40 \text{ cm}^3$  has  $6 \cdot 10^{20}$  molecules of  $\text{N}_2$  at  $40^\circ\text{C}$ . If we put in contact both containers, determine the final temperature. Assume ideal gases having only kinetic energy and consider that in the mixing the average kinetic energy is distributed equally among all particles.

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**3) (1.5 points) It is observed that one drug could bind to its protein target in two different places (site A and site B). The energy associated to the binding of the drug when it is attached to site A is of -15.5 kJ/mol, and when it is attached to the site B is of -13.7 kJ/mol. Determine at which temperature the population of the drug binding the site A is double than the population of the drug binding the site B.**

4) (1.5 points) In a study of the alcohol-dehydrogenase-catalyzed oxidation of ethanol, the molar concentration of ethanol decreased in a first-order reaction from  $220 \text{ mmol L}^{-1}$  to  $56.0 \text{ mmol L}^{-1}$  in  $1.22 \cdot 10^4 \text{ s}$  at  $25^\circ\text{C}$  and decreased in  $6.2 \cdot 10^3 \text{ s}$  at  $50^\circ\text{C}$ . a) Which is the rate constant of the reaction at  $25^\circ\text{C}$ ? Which is the rate constant of the reaction at  $35^\circ\text{C}$ ?

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**5) (1.5 points) In the first order reaction  $A \rightarrow \text{products}$ , the concentration of A is  $[A] = 0.816 \text{ M}$  at the initial time of the reaction, and  $[A] = 0.632 \text{ M}$  after 16 minutes. a) Determine the value of the rate constant b) Deduce the analytical expression of the half life for this reaction, and calculate its value. c) At which time the concentration of  $[A]$  will be  $0.235 \text{ M}$ ? Which will be the concentration of  $[A]$  at 2.5 h?**

6) (2.0 points) In the reaction  $2 A + B \rightarrow C$  at 500K, the following data were obtained

Experiment	$[A]_0/(\text{mol L}^{-1})$	$[B]_0/(\text{mol L}^{-1})$	$V_0/(10^{-3} \text{ mol L}^{-1} \text{ s}^{-1})$
1	0.26	0.26	5.4
2	0.52	0.26	10.8
3	0.52	0.52	21.6

a) Determine the partial order of A and B, and the rate constant at 500K.

b) In other experiment, if the concentration of  $[A]_0 = 0.4\text{M}$  and  $[B]_0 = 0.004\text{M}$ . Determine the rate constant of pseudo-first order. Calculate the concentration of B after 1 minute.

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**Additional data and equations:**

M(H)=1 g mol<sup>-1</sup>; M(C)=12 g mol<sup>-1</sup>; M(O)=16 g mol<sup>-1</sup>; M(N)=14 g mol<sup>-1</sup>

k<sub>B</sub>=1.3806488·10<sup>-23</sup> J K<sup>-1</sup>

R=8.314 J K<sup>-1</sup> mol<sup>-1</sup>

R=0.082 atm L K<sup>-1</sup> mol<sup>-1</sup>

N<sub>A</sub>=6.022·10<sup>23</sup> mol<sup>-1</sup>

$$v^{mp} = \sqrt{(2RT/M)}$$

$$\bar{v} = \sqrt{(8RT/(\pi M))}$$

$$v^{rms} = \sqrt{(3RT/M)}$$

$$f(v) = 4\pi \left( \frac{m}{2\pi k_B T} \right)^{3/2} v^2 e^{-mv^2/(2k_B T)}$$

$$\frac{1}{[A]_0 - [B]_0} \ln \frac{[B]_0 [A]}{[A]_0 [B]} = kt$$