Norwegian university of science and technology
Department of Physics **English**

EXAMINATION IN: MNFFY232 – BIOFYSIKK I

Date: May 10 2000 TIME: 9 – 15

Points: 4
Number of pages; 3

Permitted aids:
Mathematical tables
Calculator

Grades to be announced on: June 7 2000

Problem 1

a. Derive a mathematical expression for a so-called "random walk process" in one dimension. and calculate how the average of the squared distance $(\overline{x^2})$ of a particle from a starting point will depend upon time in such a process.

b. The random walk process is closely connected to phenomenon of diffusion. For a spherical molecule the diffusion constant D is often written as below:

$$D = kT/6\pi R\eta$$

Explain the abbreviations in this formula and discuss the origin of the denominator.

c. . Sutherland found in an experimental way that the product $D \cdot V^{1/3}$ was a constant for some fairly big molecules he used in diffusion experiments. The temperature was of course constant in his experiments. Explain this finding and also the finding that the mole weight, M, of the diffusing substance was inversely proportional to $(D)^3$.

Problem 2

The figure below shows the first registration of an action potensial from a nerve fiber as Alan Hodgkin published it in 1939.

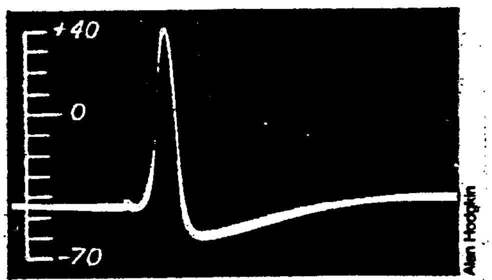

Figure 1b ***The first recording that was ever made of an action potential***

a. . Describe the action potential across the nerve membrane

b. Give a description of the Hodgkin-Huxley "Voltage Clamp Method" and how it can be used to study the action potentials.

Problem 3

The formula for the nitrogen molecule, N_2, is often written N≡N.

Give a description of the nitrogen orbitals, first in a simple nitrogen atom, N, and second in the orbitals of the compound molecule N_2. Explain why the notation mentioned above is frequently used.

Problem 4

Proteins are synthesized in the cells on the basis of information in the DNA molecules. The order of the nucleotide bases is coding for amino acids. This so-called genetic code is the same for most organisms (some exceptions exist. For example, the sequences UAA and UAG code for glutamine in some protozoas but mean simply "stop" in most organisms investigated).

The synthesis of the proteins occur in several steps. Describe the *transcription process* and describe and discuss the *genetic code.*

Problem 5

A cell has a water conductivity coefficient of $L_w = 10^{-5}$ cm/s · bar. The intracellular hydrostatic pressure of the cell is 8 bar and the intracellular osmotic pressure 10 bar. All values are valid for a temperature of 20 ^{0}C.

The volume flux of water over a general membrane is well described by the following formula

$$J_v = L_w \,.\, \Delta\psi_w$$

where J_v is the volume flux of water and $\Delta\psi_w$ is the difference in water potential over the cell membrane.

a. Calculate the net volume flux of water at the moment when the cell is put into pure water (of the same temperature and at atmospheric pressure). Show in a simple figure how water will move across the membrane.

b. If we have water in the gas phase, the chemical potential of water can be expressed as

$$\psi_{\text{water vapor}} = (RT/V_w) \cdot \ln(\%\text{ relative humidity}/100)$$

(other terms can be neglected here).

In the formula R is the Gas Constant, V_w the partial mole volume of water and T the temperature in Kelvin. A numerical value of (R/V_w) is 4.608 bar · $(\text{Kelvin})^{-1}$

The formula has extremely important consequences since it, in fact, describes the water loss from, e.g., special plant cells to their surroundings. What will be the net volume water flux over the cell membrane when the cell is exposed to a gas phase with 97 % relative humidity? with 50 % humidity? with 25% humidity?