ASE-7816 BIOSENSORS

Examination 16.5.2012   Calculator can be used

1. What means the detection limit of a chemical sensor? Describe two methods which can be used to evaluate the detection limit. How does the detection limit relate to the noise level and dynamic range of the sensor?

2. Figure 1 shows the basic structure of a mediator based biosensor for blood glucose. Explain the operation principle of the sensor based on the figure.

3. Explain the difference between immunosensor measurements based on a) competitive binding and b) immunometric principle?

4. What means Surface Plasmon Resonance (SPR) and how this phenomenon is utilized in biosensor technique?

5. Prove that in the reaction between an antigen and antibody the change of antigen concentration $A(t)$ can be described with the following differential equation

$$dA(t)/dt = k_d(A_0 + C_0) + [k_a(A_0 - B_0) - k_d]A(t) - k_aA^2(t),$$

   where A_0, B_0 and C_0 are the initial concentrations of the antigen, antibody and AgAb-complex, respectively. k_a is the association constant, and k_d dissociation constant of the reaction.

6. An antibody (MW 150000, two binding sites) was immobilized (density 40 ng/mm^2) on the surface of a quartz crystal (diameter 20 mm). In an immunoassay a sample cuvette (inside dimensions: 10 mm x 10 mm x 0.4 mm) of a FIA system was pressed against the crystal. With a buffer solution the resonant frequency of the crystal was measured to be 10.023 MHz. When an injected sample had filled the cuvette the pump of the FIA system was stopped. After a certain waiting time the resonance frequency stabilized with the change of $\Delta f = -218$ Hz. Calculate what was the concentration of the measured antigen (MW 80000, diffusion constant 10^{-10} m^{2}s^{-1}) in the sample. Reaction rate constants were $k_a = 10^8$ M^{-1}s^{-1} and $k_d = 10^{-2}$ s^{-1}. The diameter of the electrode of the crystal was 6 mm and thickness 2 μm. Mass sensitivity of a quartz crystal is

$$S = \frac{\Delta f}{\Delta m} = k_1 \frac{f_0^2}{A},$$

   where the material coefficient of quartz is $k_1 = -2.3 \cdot 10^{-7}$ m^2 s kg^{-1}. Avogadro's number is $N_0 = 6.02205 \cdot 10^{23}$ mol^{-1}.