BME Midterm exam. 2009-04-28 <u>closed book</u>

Department: **Student number:** **Name:**

1. (1) Science is seen as the pursuit of ( ). Profession is viewed as providing a ( ) to clients who have problems they cannot handle themselves. A final attribute of professionals is that of ( ).

(2) ECG is Electro( )gram; ERG is Electro( )gram; EOG is electro( )gram; EEG is electro( )gram; EMG is electro( )gram.

(3) What is the name of the displacement transducer that uses transformers?

(4) Briefly describe why an Ag/AgCl electrode makes a good reference electrode.

(5) Draw the equivalent circuit of a metal-saline interface. Describe what each component in the circuit indicates. (for example Rsp=spreading resistance of the saline.)

2. Answer the following about the neuron model:

(1) Write down the Goldman equation which describes a resting potential across a neuron membrane when three ions (K, Na and Cl ions) are present. Using it, explain the change of membrane potential during active state.

(2) Alternatively we can look at the membrane potential using the Hodgkin-Huxley equivalent circuit (or so-called Parallel Conductance Model.) Draw this circuit.

(3) Describe the voltage clamp experiments Huxley and Huxley performed to explain time dependent action potential.

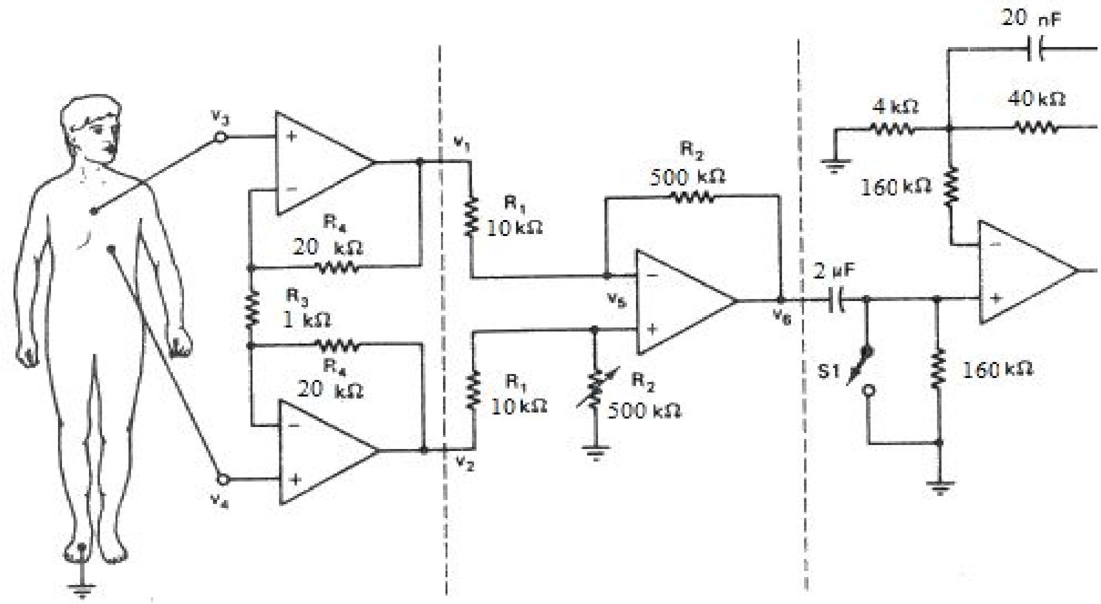
(4) Describe the Hodgkin-Huxley model of equations involving voltage dependent gates.

3. An Amplifier-Filter circuit is described for ECG measurement.

(1) What are the gains of each stages ? ( ) , ( ) , ( )

(2) What are the cut-off frequencies of high pass & low pass filters, respectively?

( ) , ( )



Stage 1 Stage 2 Stage 3

Figure : Amplifier for ECG measurement

4. Surface plasmon resonance (SPR) is a phenomenon well understood and it is based on the transfer of light energy to a group of electrons (called a plasmon) on a metal surface. Incident light is coupled into the surface plasmon by means of a prism on the metal surface, but only at a specific angle. This angle is called by the 'resonance angle'. As shown below, when the surface is exposed to an antigen that interacts with an antibody immobilized at the metal surface, the antibody-antigen interaction results in a change in the surface condition. This change causes a shift in the resonance angle. Thus, the shift between the initial and final resonance angle provides a quantitative measurement of the amount of interaction, or binding.

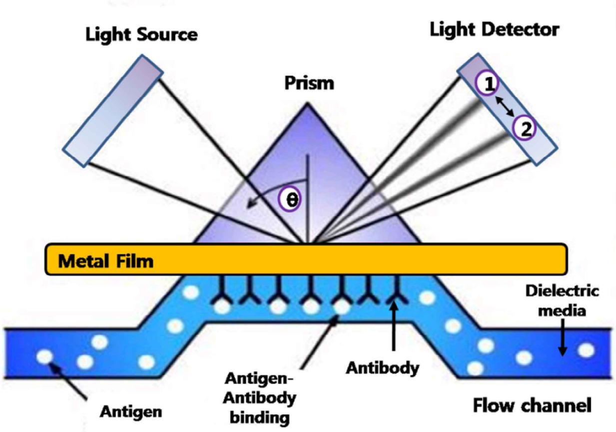


Figure: The basic concept of an angle modulated SPR sensor

The resonance angle of the surface plasmon condition is determined by the relationship of two wave propagation vectors;

$$K_x = (2\pi/\lambda)\, n_p \sin\theta \qquad K_{sp} = (2\pi/\lambda)\, [(n_m^2\, n_d^2)/(n_m^2 + n_d^2)]^{1/2}$$

where K_{sp} and K_x are wave vectors of the surface plasmon and incident light, respectively. When these two wave vectors are equal in magnitude, we can say that the incident light is coupled into the surface Plasmon and the resonance has occurred. Values of other characteristic parameters are also listed in the Table below.

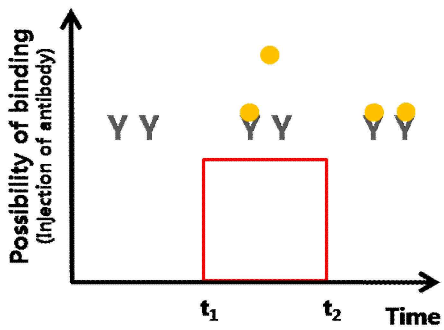
Table: Values of other characteristic parameters

Character	Explanation	Initial value
λ	Wavelength of incident light	630 nm
n_p	Refractive index of the prism	1.47
n_m	Refractive index of the metal film	1.35
n_d	Refractive index of the dielectric	1.33
θ	Resonance angle	

(1) Calculate the initial value of the resonance angle (θ). Draw the initial reflectance curve (x-axis: angle of incidence, y-axis: reflectance) before the antigen-antibody binding.

(2) The binding of antigen-antibody results in a change in refractive index of the dielectric to 1.44. Now calculate the final value of the resonance angle and draw the new reflectance curve overlaid with the previous drawing. Label the curves according to the numbers (1&2) in the figure (numbers you see in the Light Detector).

(3) When the binding occurs for the time course given in the figure below, what would be the time course change of the reflectance? Draw it.



(Appendix: Table of the arcsin x)

x	arcsin(x)	x	arcsin(x)	x	arcsin(x)
0.70	44.43	0.65	40.54	0.60	36.87
0.69	43.63	0.64	39.79	0.59	36.16
0.68	42.84	0.63	39.05	0.58	35.45
0.67	42.07	0.62	38.32	0.57	34.75
0.66	41.30	0.61	37.59	0.56	34.06