Menofia University
Faculty of Electronic Eng., Menof
Final-Term Exam, for 3rd year

Medical Electronics
Time Allowed: 3 H
12 January 2020

Answer the following questions:

Question 1 [20 Marks]

[1-a] Define the following terms: The resting potential, hyperpolarization, ion pump, sensitivity and depolarization.

[1-b] Compute the change in Vm due to a current pulse through the cell membrane for the circuit shown in figure 1.

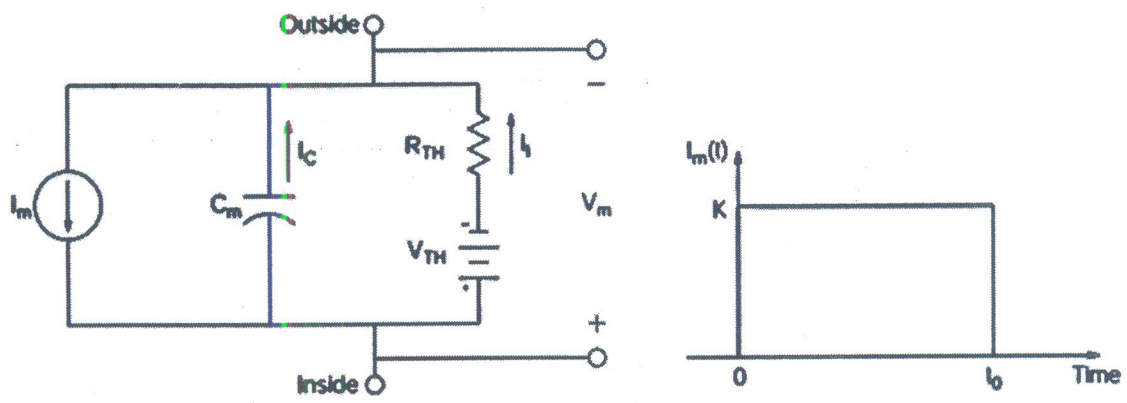

Figure 1

[1-c] A membrane is permeable to K^+ and Cl^-, but not to a large cation R^+ as shown in figure 2. Find the steady-state concentration for the following initial conditions.

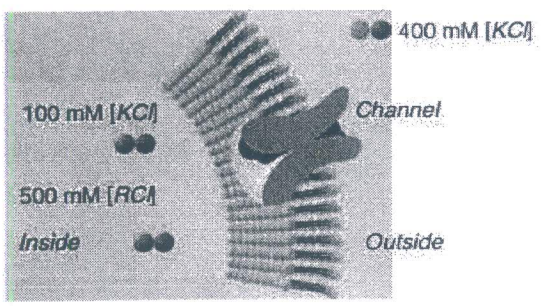

Figure 2

Question 2 [15 Marks]

[2-a] Draw the equivalent circuit model for the cell membrane and find the Thevenin's equivalent circuit of the model.

[2-b] Drive the equation of resting potential of a membrane permeable to one Ion.

[2-c] For the following circuit shown in figure 3, find V3.

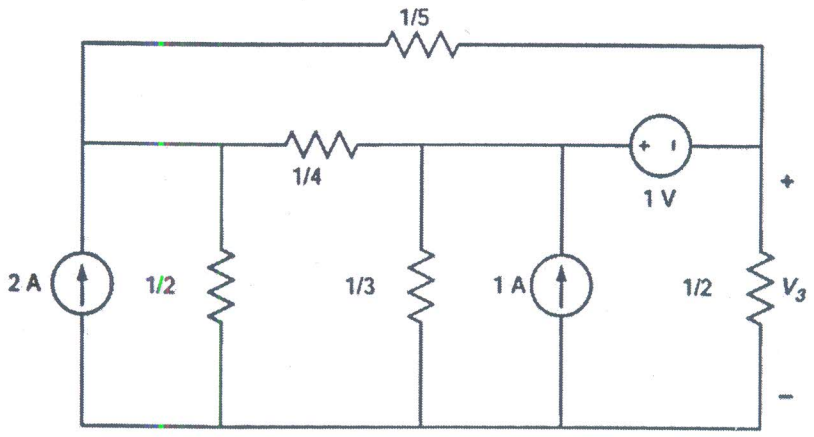

Figure 3

Question 3 [15 Marks]

[3-a] Draw the equivalent circuit model for the cell membrane and find the Thevenin's equivalent circuit of the model.

[3-b] Derive the Goldman equation for a membrane in which Na^+, K^+, and Cl^- are the only permeable ions.

[3-c] Find v in the following circuit shown in figure 4.

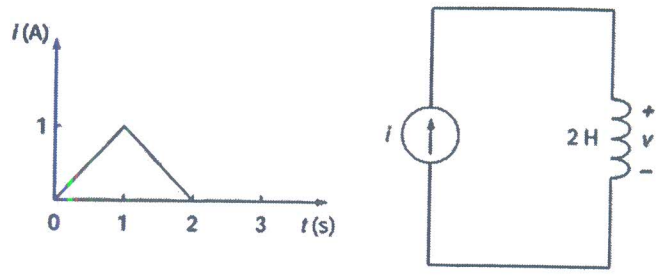

Figure 4

Question 4 [20 Marks]

[4-a] Consider a membrane in which there is an active K+ pump, passive channels for K+ and Cl-, and a non-steady-state initial concentration of [KCl] on both sides of the membrane. Find an expression for the active K+ pump.

[4-b] Find the overall gain for the following circuit shown in figure 5.

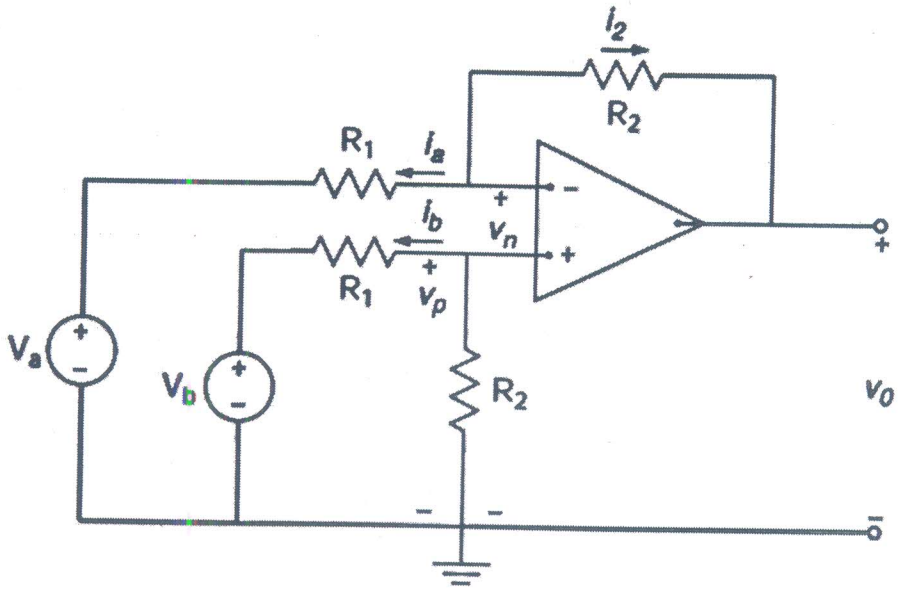

Figure 5

[4-c] Discuss the important considerations in the selection of materials for packaging of an implantable biosensor.

Question 5 [20 Marks]

[5-a] Discuss how the inductive Displacement Transducers work.

[5-b] Derive a relationship for calculating the output voltage across a piezoelectric transducer that has a thickness, d, and area, A, in terms of an applied force, F.

[5-c] The calibration tests of a new pressure transducer produced the readings in following table.

(a)Plot the input-output calibration for this transducer.

(b) Find the offset for readings between 0 to 200 mmHg.

(c) Find the sensitivity for readings between 0 to 200 mmHg.

(d) Estimate the average sensitivity for readings ranging between 200 to 300 mmHg.

(e) State whether the response of this transducer over the entire measurement range is linear or nonlinear.

Pressure(mmHg)	**20**	**40**	**60**	**80**	**100**	**120**	**140**	**160**	**180**	**200**	**220**
Reading (μV)	**0**	**20**	**40**	**60**	**80**	**100**	**120**	**135**	**150**	**165**	**180**

Pressure(mmHg)	**240**	**260**	**280**	**300**	**320**	**340**	**360**	**380**	**400**	**420**	**440**
Reading (μV)	**19**	**200**	**210**	**220**	**225**	**230**	**235**	**237**	**239**	**240**	**240**