FYSE301 Electronics 1A **Exam 03/26/2010**

Time: 4 h **Examiner: Veikko Linko**

Answer all five (5) questions! Maximum points awarded are 5 x 6p = 30p.

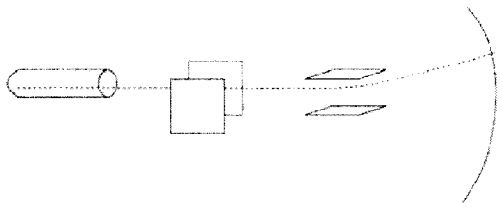
Return all your answering sheets! You may keep this exercise sheet.

1. Explain in short but understandably

a) Band structure (energy bands). Sketch band structures for a conductor, insulator and a semiconductor. Include occupation of bands in your sketches. (2p)

b) Thevenin and Norton's theorems and equivalence of voltage and current sources. (2p)

c) Name the parts of the analog oscilloscope in the figure below and add the deflection voltages v_x and v_y to the picture. Explain to which part the signal is connected and how the time sweep is done. (2p)

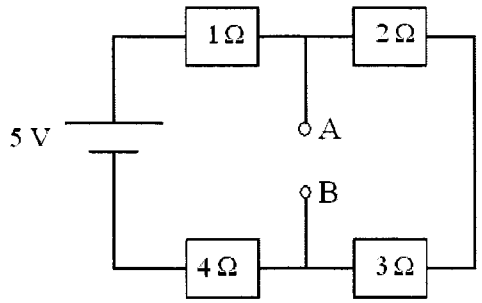


2. Linear circuits.

Calculate the voltage between nodes A and B in the circuit below. Find the current through a component connected between A and B when it is a

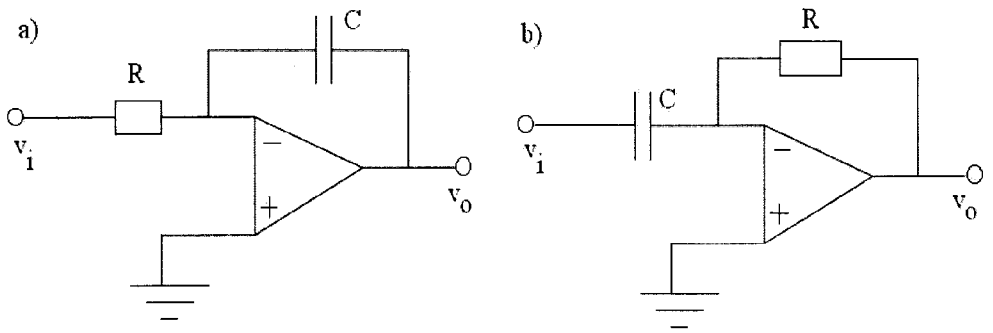
a) resistor with resistance R = 5 Ω.

b) Ge-diode (forward biased), for which the current through it, i, is a function of voltage across the diode, v: $i(v) = I_0 (\exp(v/V_0) - 1)$. Here $I_0 = 1$ μA and $V_0 = 26$ mV. (altogether 6 p)



3. Operational amplifier.

Find the output voltage v_o as a function of the input voltage v_i and state the operation that the circuit performs for both figures a and b. (altogether 6 p)



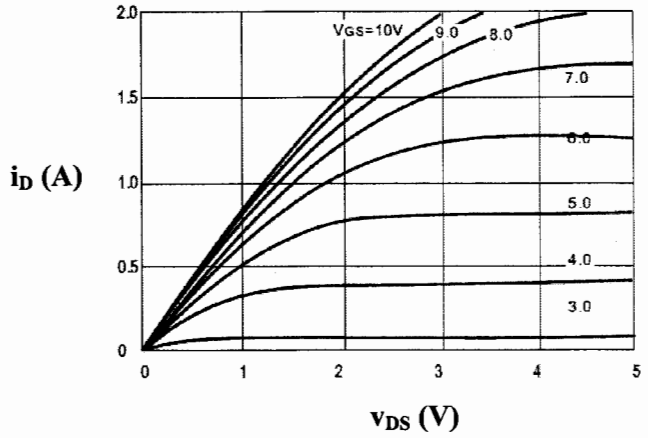
4. Semiconductors.

a) Explain how a depletion region is formed in the proximity of the pn-junction when it is not connected to a circuit. Start from the situation where p and n type semiconductors are brought to contact with each other. You may use figures as a part of your explanation. Sketch the charge density, electric field, and electric potential for the depletion region in the direction normal to the pn-interface. (4p)

b) How do the currents across the pn-junction caused by majority and minority charge carriers change, when an external voltage bias is connected across the junction? Consider both reverse and forward biases and sketch the total current through the pn-junction as a function of external voltage on the basis of your explanation. (2p)

5. Transistors.

a) Draw a cross section figure of the NMOS enhancement mode transistor. Name the semiconductor types and gate, source and drain in your figure. Explain the operating principle of the enhancement-mode NMOS and (qualitatively) the characteristic i_D-v_{DS} –curves below for different values of v_{GS}. (3p)



b) The figures below show two circuits with a bipolar junction transistor. They have the same operating point when the current-transfer ratio $\beta = 100$. If β changes 10 %, the voltage between the collector and emitter (U_{CE}) in the left circuit changes approximately 6 %. How many percent does U_{CE} in the right circuit change when β changes 10 %?
E = 10.7 V, U_{BE} = 0.7 V, R_1 = 1 MΩ, R_2 = 4 kΩ, R_3 = 606 kΩ, R_4 = 4 kΩ. (3p)