Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ USC ID#: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

I hereby affirm that all the answers below are my own. I have neither searched online nor taken assistance from any external entity.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Student Signature Above

EE105 – Fall 2024

Midterm

Time Limit: 2 hours

Section 1: /25

Section 2: /25

Section 3: /25

Total: /75

Total number of pages is 12 (including this page). Put your name on every page where noted

**Section A (25 points)**

**Question 1 (3 points)**

Given the circuit diagram with nodes **A, B,** and**C**, each connected to **3V** sources as shown. Determine the voltages **VA​, VB​,** and **VC**​ at the respective nodes with respect to the ground.

A diagram of a circuit

Description automatically generated

**Question 2 (3 points)**

Given the circuit with nodes **A, B, C,** and **D** as shown. Calculate the following **VAB, IAB,** and **ICD**.

**A diagram of a circuit

Description automatically generated**

**Question 3(8 points)**

Given the circuit with six resistors connected to a **3V** voltage source as shown. Find voltages across the resistors (**VA, VB, VC, VD, VE,** and **VF**) and current through resistors (**IA, IB, IC, ID, IE,** and **IF**).

A diagram of a circuit

Description automatically generated

**Question 4 (3 points)**

The circuit below contains a voltage source, and a resistor labeled **R**. Using the provided ammeter symbol, place the ammeter correctly in the circuit to measure the current **IR**. Redraw the modified circuit with the ammeter in place.

A diagram of a circuit

Description automatically generated

**Question 5 (8 points)**

1. Apply Kirchhoff's Current Law (KCL) at nodes A, B, C, D, E, F, and G in the given circuit. Write the current equations for each respective node. Assume the currents through resistors R1, R2, R3, R4, …, R11 as I1, I2, I3, I4, …, I11​.
2. If I1 = 1A, Calculate the values of currents I2, I3, I4, I5, I6, I7, I8, I9, I10, and I11. All the resistors in the below circuit have equal resistance.

**A diagram of a circuit

Description automatically generated**

**Section B (25 points)**

**Question 6 (3 points)**

The graph below shows the band structure of two different semiconductors. Identify which semiconductor would be more suitable for optoelectronic applications. Explain your reasoning.

**A diagram of electrical energy

Description automatically generated with medium confidence**

**Question 7 (4 points)**

The diode shown below is arranged in two different configurations with a variable voltage source that provide 0 to +3V. Draw the IV characteristics of the diode for each configuration. Use the provided empty plots to answer the question.

A black line on a white background

Description automatically generated

A black line with a white background

Description automatically generated A black line with a white background

Description automatically generated

**Question 8 (3 points)**

An LED is connected to a 1V voltage source in series with a 100-ohm resistor, as shown below. Using the provided LED characteristic curve, determine the value of I (the current through the LED).

A diagram of a circuit

Description automatically generatedA graph with a line

Description automatically generated

**Question 9 (4 points)**

In a photodiode, identify the region where light is captured. Draw a diagram of the photodiode and indicate the light-capturing region.

**Question 10 (3 points)**

The diagrams below show two different configurations of photodiodes. Identify which configuration is more effective for capturing light. Explain the reason for your choice.

A black triangle with a white background

Description automatically generated

**Question 11 (3 points)**

The curve below shows the VDS​ vs. ID characteristics of a MOSFET. **Label** and **mark** the different regions of operation on the curve (e.g., cutoff, triode, and saturation regions). Use the provided graph for labeling; no need to draw a new graph.

A diagram of a function

Description automatically generated

**Question 12 (5 points)**

An NMOS is arranged in the configuration shown below. Calculate the voltage across the resistor RD and the current through RD. Use the following parameters for your calculations:

VDD = 8V, VGS = 3V, VTh = 1V, RD = 1KΩ, and ​ = 0.2 .

A math equations with numbers and symbols

Description automatically generated with medium confidence **A diagram of a circuit

Description automatically generated**

**Section C (25 points)**

**Question 13 (4 points)**

The circuit below includes a thermistor. Solve the equation for RT​ (thermistor resistance). The solution should be expressed as a function of Vout.

**A diagram of a voltage

Description automatically generated**

**Question 14 (3 points)**

An operational amplifier (Op-Amp) is connected to two distinct resistor networks as illustrated below. Calculate the output voltage (Vout​). Assume that the amplification factor (A) is equal to 1.

A diagram of a circuit

Description automatically generated

**Question 15 (4 points)**

An operational amplifier (Op-Amp) is connected with resistors as shown below. Derive the expression for the output voltage (Vout​) in terms of the input voltage (Vin).

**A diagram of a circuit

Description automatically generated**

**Question 16 (6 points)**

Two operational amplifiers (Op-Amps) are connected in a cascaded configuration as illustrated in the circuit below. Derive the expression for the output voltage (Vout) in terms of the input voltage (Vin​).

A diagram of a circuit

Description automatically generated

**Question 17 (3 points)**

Remember the oximeter from your demo board used during the class? Identify all the systems involved in capturing data from the physical world and displaying it on a computer. Fill in the provided blank blocks to complete the system diagram.

**A black and white square with black lines

Description automatically generated**

**Question 18 (3 points)**

Using the provided information, calculate the oxygenation (SpO2) of the person:

RedAC = 40mV, RedDC = 600mV, NIRAC = 20mV, and NIRDC = 300mV  
SpO2 = 110 – 25 x ROS, determine if the person requires supplemental oxygen based on the calculated SpO2?

**Question 19 (2 points)**

How many LEDs are required for the oximeter with oxy- and dexoy-hemoglobin optical absorbance depicted in the graph? Explain your rationale.

A graph of a wave length

Description automatically generated with medium confidence