International Islamic University Chittagong
Department of Electrical and Electronic Engineering

Final Examination Spring-2018	Program: B.Sc. Engg. (EEE)
Course Code: **EEE-3607**	Course Title: **Solid State Devices**
Time: **2hours 30 minutes**	Full Marks: **50**

Use separate script for each part. Figures in the right margin indicate full marks.

Part-A

[Answer any ***two*** questions from the followings]

1(a). Determine and explain the contact potential of a p-n junction in terms of its electric field distribution. Also determine an expression for the width of the transition region. **4**

1(b). An abrupt Si p-n junction, having a circular cross with a diameter of 10 μm, has $N_a = 10^{18}$ cm^{-3} on one side and $N_d = 5 \times 10^{15}$ cm^{-3} on the other. The contact potential is 0.796 eV and the relative permittivity is 11.8. Calculate x_{no}, x_{po}, Q_+, and $\mathcal{E}_o$ for this junction at equilibrium (300 K). Sketch $\mathcal{E}(x)$ and charge density to scale. **6**

2(a). With proper sketch, determine the excess hole distribution in the neutral base region of a p-n-p transistor under forward-bias condition. **4**

2(b). An abrupt Si p-n junction ($A = 10^{-4}$ cm^2) has the following properties at 300 K: **6**

p side	**n side**
$N_a = 10^{17}$ cm^{-3}	$N_d = 10^{15}$
$\tau_n = 0.1$ μS	$\tau_p = 10$ μS
$\mu_p = 200$ cm^2/V-s	$\mu_n = 1300$
$\mu_n = 700$	$\mu_p = 450$

The junction is forward-biased by 0.5 V. What is the forward current? What is the current at a reverse bias of -0.5 V?

3(a). Determine the base current and collector current from the following network in **Fig.1** below. The average hole lifetime in the base is 10 μs and transit time for hole from emitter to collector is 0.1 μs. **3**

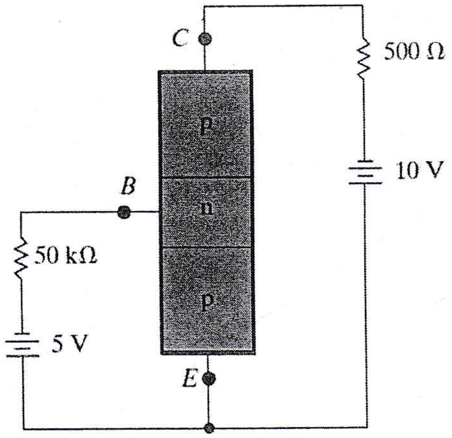

Fig.1: For Question **3(a)**.

3(b). Determine the total current at any point in a p-n junction, with neat sketch, from the slopes of the excess minority carrier distributions at the two edges of the transition region. **5**

3(c). Draw the potential barrier and energy band diagram for a p-n junction in equilibrium, forward-biased, and reverse-biased condition. 2

Part- B

[Answer any *three* questions from the followings]

4(a). Derive and explain the Ebers-Moll equations. Draw an equivalent circuit synthesizing the Ebers-Moll equations. 6

4(b). Determine the pinch-off voltage of a field-effect transistor in terms of its doping concentrations. Sketch the relevant diagrams. 4

5(a). Explain, with relevant diagram, how a MOSFET acts like a gate-controlled potential barrier. 4

5(b). Explain why JFET and Depletion-MOSFET is normally in 'ON' state while Enhancement-MOSFET is in 'OFF' state. 3

5(c). Briefly explain hot electron effect. 3

6(a). Explain, with relevant diagram, the photocurrent generation in a solar cell. 4

6(b). Explain external quantum efficiency. 2

6(c). A solar cell under an illumination of 500 W m^{-2} has a short-circuit current of 150 mA and an open-circuit voltage of 0.530 V. What are the short-circuit current and the open-circuit voltage when the light intensity is doubled? Assume $\eta = 1.5$. 4

7(a). Determine the mathematical expression for saturated drain current in a JFET. 4

7(b). Explain the variation in photon energy obtainable from gallium arsenide phosphide. 2

7(c). Consider the following I-V curve in the **Fig.2** below of a solar cell driving a load of 3 Ω. The cell has an area of 3 cm × 3 cm and is illuminated with light of intensity 700 W m^{-2}. Find the current and voltage in the circuit. Find the power delivered to the load, the efficiency of the solar cell in this circuit, and the fill factor of the solar cell. 4

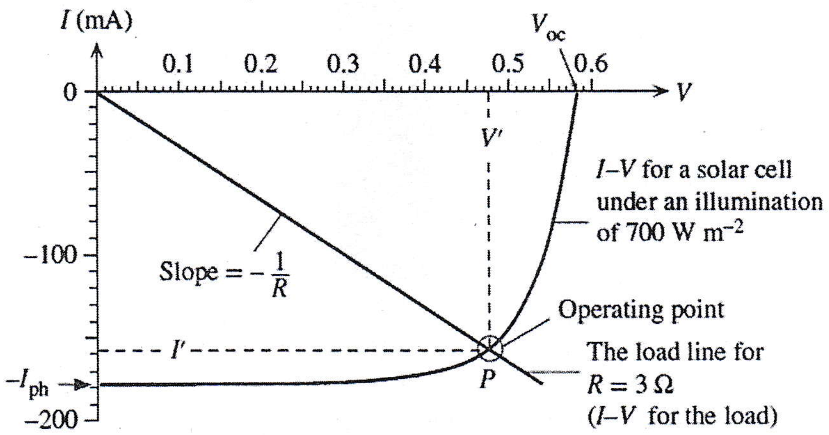

Fig. 2: For Question 7(c).