

Self-assessment test for the application to the master programme Micro- and Nanotechnologies at TU Ilmenau

Scope

This test is for your own assessment in order to give you confidence that you are prepared for this master program.

Note

You should be able to answer most of these questions based on your previous studies in engineering bachelor programs with strong electrical engineering, technological and material science background. Some are made in a multiple-choice format whereas other require written answers. If you are unable to answer the majority of questions, you should reconsider to apply for this master programme.

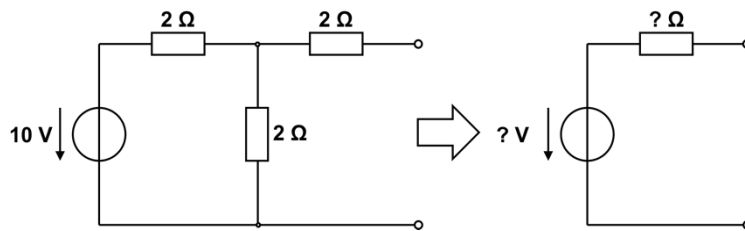
1. Electrical Engineering and Electronics

- 1.1. Give Maxwell's equations in differential form.
- 1.2. Explain the role of the magnetic vector potential.
- 1.3. What is the difference between Laplace's and Poisson's equation?
- 1.4. What kind of equation is governing the penetration of ac fields and currents into conductors?
- 1.5. Apply Biot-Savart's formula to line currents.
- 1.6. Mention approaches for calculating inductances.
- 1.7. What kind of metal-semiconductor contacts exist?
 - a Schottky contact
 - b Ohmic contact
 - c p-n-contact
 - d Diffusion contact
 - e Space charge contact
- 1.8. Which chemical formulas are true for the oxidation of silicon?
 - a $\text{Si} + \text{O}_2 \rightarrow \text{SiO}_2$
 - b $\text{Si} + 2\text{H}_2\text{O} \rightarrow \text{SiO}_2 + 2\text{H}_2$
 - c $\text{Si} + \text{H}_2\text{O} \rightarrow \text{SiO}_2 + \text{H}_2$
 - d $\text{Si} + 2\text{HNO}_2 \rightarrow \text{SiO}_2 + 2\text{NO} + \text{H}_2\text{O}$
 - e $\text{Si} + 2\text{HNO}_2 \rightarrow \text{SiO}_2 + 2\text{NO}_2 + \text{H}_2\text{O} + \text{O}$

1.9. Which processes for the production of thin films are used in microtechnology (among others)?

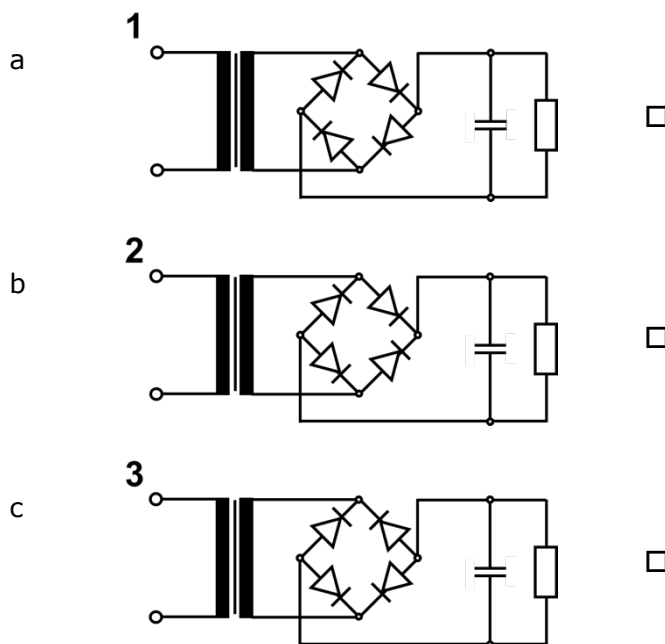
- a Chemical vapor deposition (CVD)
- b Physical vapor deposition (PVD)
- c Sputtering
- d Atomic layer deposition (ALD)
- e Plasma ashing
- f Chemical mechanical polishing (CMP)

1.10. Transform the given circuit in its equivalent circuit and calculate the values for the equivalent resistance and the equivalent voltage.



- a 4 V and 5 Ω
- b 5 V and 3 Ω
- c 6 V and 2 Ω
- d 2 V and 6 Ω
- e 3 V and 4 Ω

1.11. Given are the following three circuits. Which of these circuits work as a rectifier?



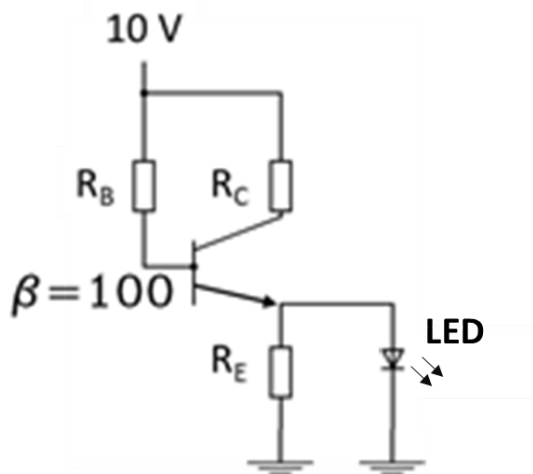
1.12. Which of the following junctions has the smallest depletion width? Note that the "+" sign means heavily doped.

- a P/N junction
- b P+/N junction
- c P/N+ junction
- d P+/N+ junction

1.13. What is the advantage of using amorphous silicon as the material for solar cell when compared with single crystal silicon?

- a It is more efficient in converting light energy to electrical energy
- b It is more stable
- c It can be formed at lower temperature
- d It has lower internal resistance

1.14. Consider the illustrated circuit. At which condition the LED with a forward voltage of 0.6V will be turned ON?



- a $R_B: 1k\Omega, R_C 100\Omega, R_E 10\Omega$
- b $R_B: 1k\Omega, R_C 1k\Omega, R_E 100\Omega$
- c $R_B: 100\Omega, R_C 100\Omega, R_E 100\Omega$
- d $R_B: 1M\Omega, R_C 1M\Omega, R_E 1\Omega$

1.15. A semiconductor is formed by bonds.

- a covalent
- b electrovalent
- c co-ordinate
- d none of the above

- 1.16. When a pure semiconductor is heated, its resistance
- a goes up
 - b goes down
 - c remains the same
 - d can't say
- 1.17. When a pentavalent impurity is added to a pure semiconductor, it becomes
- a an insulator
 - b an intrinsic semiconductor
 - c p-type semiconductor
 - d n-type semiconductor
- 1.18. An n-type semiconductor is
- a positively charged
 - b negatively charged
 - c electrically neutral
 - d none of the above
- 1.19. A hole in a semiconductor is defined as
- a a free electron
 - b the incomplete part of an electron pair bond
 - c a free proton
 - d a free neutron
- 1.20. In a semiconductor, current conduction is due to
- a only holes
 - b only free electrons
 - c holes and free electrons
 - d none of the above
- 1.21. Which kind of transport mechanism of holes and electrons is driven by a concentration gradient?
- a diffusion
 - b drift
 - c ionisation
 - d none of the above

1.22. In an intrinsic semiconductor, the number of free electrons

- a equals the number of holes
- b is greater than the number of holes
- c is less than the number of holes
- d none of the above

1.23. The term bias in electronics usually means

- a the value of ac voltage in the signal
- b the condition of current through a pn junction
- c the value of dc voltages for the device
- d the status of the diode

1.24. A discrete MOSFET has terminals

- a two
- b five
- c four
- d three

1.25. A MOSFET can be operated with

- a negative gate voltage only
- b positive gate voltage only
- c positive as well as negative gate voltage
- d none of the above

1.26. A MOSFET is sometimes called field effect transistor

- a many gate
- b open gate
- c insulated gate
- d shorted gate

1.27. Which of the following devices has the highest input impedance?

- a JFET
- b MOSFET
- c Chrystal diode
- d Bipolar transistor

1.28. The input impedance of a MOSFET is of the order of

- a Ω
- b a few hundred Ω
- c $k\Omega$
- d several $M\Omega$

1.29. A MOSFET uses the electric field of a to control the channel current

- a capacitor
- b battery
- c generator
- d none of the above

1.30. A certain p-channel E-MOSFET has $V_{GS(th)} = -2V$. If $V_{GS} = 0V$, the drain current is

- a 0 mA
- b $I_{D(on)}$
- c maximum
- d I_{DSS}

1.31. The diffusion capacitance is the term to refer to

- a the reverse bias capacitance of a diode
- b the forward bias capacitance of a diode
- c the breakdown capacitance of a Zener diode
- d the effective capacitance of the rectifier

1.32. How do the breakthrough voltages of the Zener effect and of the avalanche effect depend on temperature?

- a both are independent of the temperature
- b the breakthrough voltage of the Zener effect increases with increasing temperature,
- c the breakthrough voltage of the avalanche effect increases with decreasing temperature
- d the breakthrough voltage of the avalanche effect decreases with increasing temperature
- e none of the above

1.33. A diode is biased with a higher reverse voltage. The transition region capacitance

- a is charging
- b is being discharged
- c increases
- d decreases

1.34. In which operational modes are MOSFETs used in digital circuits?

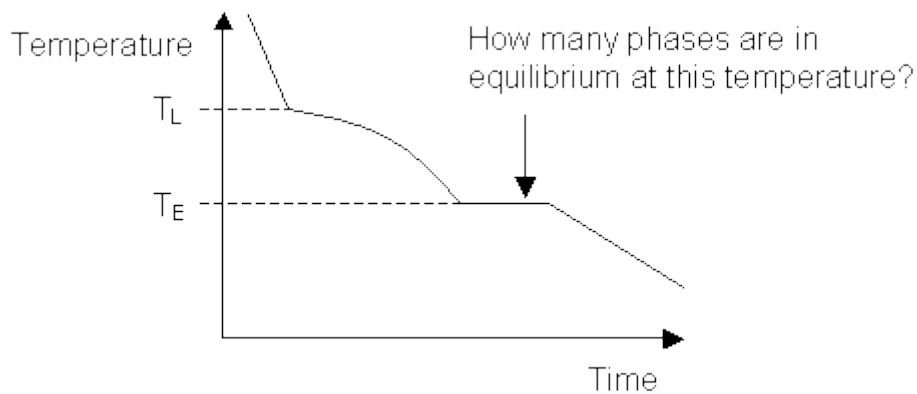
- a Saturation and cut-off mode
- b triode and saturation mode
- c triode and cut-off mode
- d none of the above

1.35. The relation between α and β of a BJT is

- a $\alpha = \frac{\beta + 1}{\beta}$
- b $\beta = \frac{\alpha}{1 - \alpha}$
- c $\beta = \frac{1}{1 + \alpha}$
- d $\alpha = \frac{\beta}{\beta + 1}$

2. Material Science and Mechanics

2.1. How many phases are in equilibrium at this temperature?



- a one phase
- b two phases
- c three phases
- d four phases

2.2. What is Fick's 2nd Law?

- a $J = D \left\{ \frac{\partial^2 C}{\partial x^2} \right\}$
- b $\frac{\partial C}{\partial t} = D \left\{ \frac{\partial^2 C}{\partial x^2} \right\}$
- c $J = v_0 \exp \left(\frac{-G^*}{k_B T} \right)$

2.3. Which of the following is false?

- a Quartz crystals have optically anisotropic properties.
- b Glass has no regular repeating crystalline structure.
- c Certain crystals may cleave easily along certain planes, defined by the crystal structure.
- d Crystal defects are not found in single crystals.

2.4. How can you classify materials, and which different classes of materials have you in mind?

2.5. Many metallic materials have fcc or bcc crystalline systems. What do fcc and bcc state for?

2.6. In polycrystalline materials, texture is an important microstructural feature which has influence on physical properties. What is texture?

2.7. What is eutectic system and eutectic temperature?

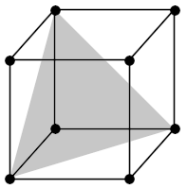
2.8. What is the best term to describe the electrical conductivity of silicon?

- a superconducting
- b semiconducting
- c senileconducting
- d softconducting
- e spareconducting

2.9. What are Miller indices?

- a notation system in materials purity
- b notation system for miniaturization
- c notation system in crystallography
- d notation system in exam grading
- e notation system for microactuators

2.10. How would you describe the depicted plane in the best manner if you can choose?



- a (111)-plane
- b <3-axis>-plane
- c {bcc}-plane
- d air plane
- e sp^3 -plane

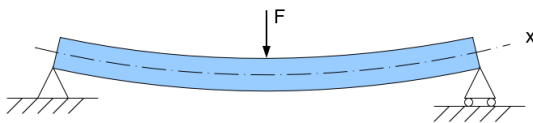
2.11. Which analytical technique would you prefer to determine the lattice parameter and crystal orientation?

- a Atomic Force Microscopy
- b Electron beam diffraction
- c X-Ray diffraction
- d UV-Photoelectron Spectroscopy
- e Jedi Force Microscopy

2.12. A conductor is $10\ \mu\text{m}$ long, has a $2\ \mu\text{m}^2$ cross section and the materials electric resistivity is $500\ \mu\Omega\text{m}$. What is the resistance of the system?

- a Not possible to calculate with only these values
- b $2500\ \text{J/m}^2$
- c $2.5\ \text{k}\Omega$
- d $25\ \text{k}\Omega\text{m}$
- e $250\ \Omega$

2.13. Which quantity is required to calculate the bending line of the depicted bending beam?



- a moment of bending time
- b moment of power
- c second moment of volume
- d moment of inertia
- e second moment of area

2.14. What is the correlation factor between mechanical stress and strain?

- a elastic modulus
- b OLD modulus
- c ECTS modulus
- d Planck modulus
- e Young's modulus

2.15. What is the angle between the two vectors (100) and (111) in single crystal silicon?

- a 90°
- b 45°
- c 54.7°
- d 35.9°
- e It is not possible to calculate an angle between two vectors.

2.16. Which quantity affects the resolution of an optical microscope?

- a numerical apparatus
- b numerical aperture
- c numerical refraction
- d index of refraction
- e wavelength of the light

2.17. If the distance between two metal plates is doubled and a constant electrical voltage of 1 V is applied between the plates. How (factor) does the capacitance change?

- a factor 0.5
- b the capacitance is not affected by the plate distance
- c factor 4
- d factor $\ln(2)$
- e factor 20

2.18. What is a piezoelectric material?

- a A material that is superconducting at room temperature.
- b A material that carries a permanent electrical current.
- c A material that shows electrical polarization upon mechanical deformation.
- d A material that creates a voltage if it is loaded with a force.
- e A material that creates electrical power if illuminated (solar cell).

2.19. Which of the following names is linked to a dimensionless quantity that describes fluidic behavior?

- a Planck
- b Reynold
- c Simpson
- d Fermi
- e Jackson

2.20. Which of the following terms belongs to wet etching technologies?

- a KOH
- b BHF
- c AC
- d RIE
- e LIGA