**EL/V/CC/14b**

**2021**

(CBCS)
(5th Semester)
**ELECTRONICS**

EIGHT (B) PAPER
**[Solid State Electronics]**

*Full Marks*: 75
*Time:* 2 *hours*

**INSTRUCTIONS TO CANDIDATES**

(Please read the instructions carefully before you start writing your answers)

1. Questions should be attempted as per instructions.
2. Do not copy the Questions. Indicate the Section and Question No. clearly while attempting the answer.
3. For Multiple choice answers, candidate should indicate the Question No., Sub. No., (if any) and the correct answer. For example :

   *1. Name the State capital of Mizoram.*

   *(a) Lunglei*

   *(b) Aizawl*

   *(c) Champhai*

   Candidate should provide answer as—Q. No. *1* : *(b) Aizawl* [Candidate should avoid writing only *(b)* ]
4. Section B - Answer to Short Answer should be limited to **One Page** only.
5. The figures in the margin indicate full marks for the questions.

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## SECTION : A – OBJECTIVE

( Marks: 30 )

Choose the correct answer from the following: 1x30=30

1. An atom is said to be ionized when any one of its orbiting electron
   (a) Jumps from one orbit to another
   (b) is raised to a higher orbit
   (c) comes to the ground state
   (d) is completely removed.

2. Semiconductor materials have ……bonds.
   (a) ionic
   (b) covalent
   (c) mutual
   (d) metallic

3. The maximum number of electrons which the valence shell of an atom can have is
   (a) 6
   (b) 8
   (c) 18
   (d) 2

4. Hall effect is observed in a specimen when it (metal or a semiconductor) is carrying current and is placed in a magnetic field. The resultant electric field inside the specimen will be in
   (a) a direction normal to both current and magnetic field
   (b) the direction of current
   (c) a direction antiparallel to the magnetic field
   (d) an arbitrary direction depending upon the conductivity of the specimen.

5. A semiconductor is known to have an electron concentration of $\times 10^{13}$ / $cm^3$ and hole concentration of $5 \times 10^{12}$ /$cm^3$. The semiconductor is
   (a) n-type
   (b) p-type
   (c) Intrinsic
   (d) none of these

6. GaAs pn junctions have been fabricated where Si was both the p-side and n-side dopant. Then this Si is the
   (a) Donor impurity
   (b) Acceptor impurity
   (c) both (a) and (b)
   (d) none

7. Current flow in a semiconductor depends on the phenomenon of
   (a) drift
   (b) diffusion
   (c) recombination
   (d) all of the above

8. The electron and hole concentration in an intrinsic semiconductor are $n_i$ and $p_i$ respectively. When doped with a p-type material, these change to n and p respectively, then:
   (a) $n+p = n_i\_p_i$
   (b) $n+n_i = p+p_i$
   (c) $np = n_ip_i$
   (d) None of the above

9. Silicon and germanium are called _____ semiconductors
   (a) direct gap
   (b) indirect gap
   (c) band gap
   (d) indirect band gap

10. The conductivity of the pure silicon is raised by:
    (a) Introducing Dopants (impurities)
    (b) Increasing Pressure
    (c) Decreasing Temperature
    (d) Deformation of Lattice

11. The n-MOS transistor is made up of:
    (a) N-type source, n-type drain and p-type bulk
    (b) N-type source, p-type drain and p-type bulk
    (c) P-type source, n-type drain and n-type bulk
    (c) P-type source, p-type drain and n-type bulk

12. The n-MOSFET is working as accumulation mode when:
    (a) Gate is applied with positive voltage
    (b) Gate is grounded
    (c) Gate is applied with negative voltage
    (d) Gate is connected to source

13. Which of the following diodes uses a metal-semiconductor junction?
    (a) General purpose diodes
    (b) Fast recovery diodes
    (c) Schottky diode
    (d) None of the mentioned

14. In which region is the temporal response of an MOS capacitor the slowest.
    (a) accumulation
    (b) flat band
    (c) depletion
    (d) inversion

15. What type of device is MOSFET
    (a) Current - controlled
    (b) Voltage - controlled
    (c) Voltage – controlled current source
    (d) Voltage – controlled voltage source

16. An MOS capacitor biased so that minority carriers in the semiconductor pile up at the oxide semiconductor interface is biased in which region?
    (a) accumulation
    (b) flat band
    (c) depletion
    (d) inversion

17. The typical high-frequency MOS capacitance is less than the low-frequency capacitance in which region(s) of operation?
    (a) Accumulation.
    (b) Depletion.
    (c) Inversion.
    (d) Accumulation and depletion.

18. Thequantity, $\varphi_F$ is a critical parameter in MOS theory. What happens when the surface potential equals $2\varphi_F$ ?
    (a) the majority carrier concentration at the surface equals the majority carrier concentration in the bulk.
    (b) the majority carrier concentration at the surface equals the intrinsic carrier concentration, $n_i$ .
    (c) the minority carrier concentration at the surface equals the intrinsic carrier concentration, $n_i$ .
    (d) the minority carrier concentration at the surface equals the majority carrier concentration in the bulk.

19. When a thyristor is negatively biased,
    (a) all the three junctions are negatively biased
    (b) outer junctions are positively biased and the inner junction is negatively biased
    (c) outer junctions are negatively biased and the inner junction is positively biased
    (d) the junction near the anode is negatively biased and the one near the cathode is positively biased

20. The minimum value of current required to maintain conduction in an SCR is called its ..... current.
    (a) commutation
    (b) holding
    (c) gate trigger
    (d) breakover

21. Which semiconductor device acts like a diode and two resistors ?
    (a) SCR
    (b) triac
    (c) diac
    (d) UJT

22. Which of the following are negative resistance microwave diodes oscillator applications ?
    (a) Gunn
    (b) IMPATT
    (c) step recovery
    (d) both (a) and (b)

23. The IP/IV ratio of a tunnel diode is of primary importance in
    (a) determining tunneling speed of electrons
    (b) the design of an oscillator
    (c) amplifier designing
    (d) computer applications

24. A LASCR is just like a conventional SCR except that it
    (a) cannot carry large current
    (b) can also be light-triggered
    (c) has no gate terminal
    (d) cannot be pulse-triggered.

25. First integrated circuit chip was developed by
    (a) C.V. Raman
    (b) W.H. Brattain
    (c) J.S. Kilby
    (d) Robert Noyce

26. An integrated electronic circuit is
    (a) a complicated circuit
    (b) an integrating device
    (c) much costlier than a single transistor
    (d) fabricated on a tiny silicon chip

27. Processing of MOS ICs is less expensive than bipolar ICs primarily because they
    (a) use cheaper components
    (b) need no component isolation
    (c) require much less diffusion steps
    (d) have very high packing density.

28. As compared to monolithic ICs, film ICs have the advantage of
    (a) better high-frequency response
    (b) much reduced cost
    (c) smaller size
    (d) less flexibility in circuit design

29. The foundation on which an IC is built is called an
    (a) insulator
    (b) base
    (c) wafer
    (d) plate

30. In the context of IC fabrication, metallization means
    (a) connecting metallic wires
    (b) forming interconnecting conduction pattern and bonding pads
    (c) depositing SiO2 layer
    (d) covering with a metallic cap.

**SECTION : B – SHORT ANSWER**

(Marks : 45)

***Answer the following questions in not more than 1 (one) page each, choosing 3 (three) questions from each unit.***

3x15=45

## Unit I

1. What do you understand by *Solid State* Electronics? Define semiconductor. List types of semiconductor with examples.
2. The lattice constant of a face-centered-cubic structure is 4.25 Å. Calculate the surface density of atoms for a (a) (100) plane and (b) (110) plane.
3. Explain Degenerate and Nondegenerate semiconductors with proper energy band diagram?.
4. Explain the formation of energy bands in terms of decreasing inter-atomic spacing for N- atoms of silicon

### Unit II

5. Explain wave-particle duality. An electron has a kinetic energy of 12 eV. Determine the de Broglie wavelength (in Å) ($m_o$ = 9.11 x $10^{-31}$ kg).
6. What is the relevance of Fermi energy? Calculate the thermal equilibrium electron and hole concentration in silicon at T = 300 K for the case when the Fermi energy level is 0.22 eV below the conduction-band energy $E_c$. ( The value of $E_g$ is 1.12 eV, $N_c$ = 2.8 x $10^{19}$ $cm^{-3}$, $N_v$ = 1.04 x $10^{19}$ $cm^{-3}$, k = 1.38 x $10^{-23}$ J/K)
7. Discuss the concept of charge neutrality. The concentration of donor impurity atoms in silicon is $N_d$ = $10^{15}$ $cm^3$. Assume an electron mobility of $\mu_n$ =1300 $cm^2$/V-s and a hole mobility of $\mu_p$ =450 $cm^2$/V-s. (a) Calculate the resistivity of the material. (b) What is the conductivity of the material?
8. Explain why the polarity of the Hall voltage changes depending on the conductivity type (n type or p type) of the semiconductor.

**Unit III**

9. Construct the equilibrium energy band diagram appropriate for an ideal p-type semiconductor to metal where $\Phi_M < \Phi_S$. Also give the conditions of rectifying and ohmic MS contact for both n-type and p-type semiconductor.
10. Determine the theoretical barrier height, built-in potential barrier, and maximum electric field in a metal–semiconductor diode for zero applied bias. (Consider a contact between tungsten and n-type silicon doped to $N_d = 10^{16}$ cm$^3$ at T = 300 K, $\phi_m$ = 4.55 V, $\chi$ = 4.01 V, $N_C = 2.8 \times 10^{19}$)
11. Explain C-V curve for MOS capacitor at low frequency. A MOS capacitor has oxide thickness $t_{ox}$ of 50 nm. Determine the capacitance.
12. Construct energy band diagram for MOS capacitor corresponding to (a) *accumulation, (b) weak inversion, (c) depletion, (d)strong inversion* . (Use p-type semiconductor)

**Unit IV**

13. Explain Tunnel Diode V-I characteristics with its corresponding energy band diagram.
14. Describe how a negative differential resistance characteristic is produced in the IMPATT diode
15. a) A GaAs transferred-electron device has a doping concentration of $N_d = 10^{15}$ cm$^3$. Determine (i) the minimum device length, (ii) the time between current pulses, and (iii) the oscillation frequency (assume $v_d = 1.5\ 10^7$ cm/s).
16. What are breakdown devices? Briefly explain the working of SCR.

**Unit V**

17. Explain Integrated Circuits and its classifications based on structure and function
18. Briefly explain photolithography with example.
19. Discuss Integrated Circuits based on MOS and Bipolar Technology.
20. How Many levels of integration are there in Integrated Circuits?

***** End of question *****